AMERICAN MUSEUM
Novitates

PUBLISHED BY THE AMERICAN MUSEUM OF NATURAL HISTORY
CENTRAL PARK WEST AT 79TH STREET, NEW YORK, N.Y. 10024
Number 3201, 44 pp., 24 figures, 1 table August 29, 1997

Campanian Ammonites from the Tombigbee Sand Member of the Eutaw Formation, the Mooreville Formation, and the Basal Part of the Demopolis Formation in Mississippi and Alabama

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ABSTRACT

The upper part of the Tombigbee Sand Member of the Eutaw Formation and the Mooreville Formation in Mississippi and Alabama yield ammonite faunas of the *Submortoniceras tequesquitense* zone, *Menabites (Delawarella) delawarensis* zone, and *Baculites taylorensis* zone (new term) of the Gulf Coast sequence. These zones can be correlated with the more refined zonation developed in the U.S. Western Interior. The following species are described: *Pachydiscus (Pachydiscus)* aff. *travisi* (Adkins, 1929), *Pachydiscus (Pachydiscus) paulsoni* (Young, 1963), *Placenticeras placenta* (DeKay, 1828), *Placenticeras syrtale* (Morton, 1834), *Hoplitoplacenticeras (Hoplitoplacenticeras)* sp., *Texanites (Texanites) lonsdalei* Young, 1963, *Texanites (Plesiotexanites) shiloensis* Young, 1963, *Submortoniceras tequesquitense* Young, 1963, *Menabites (Delawarella) delawarensis* (Morton, 1834), *Menabites (Delawarella) vanuxemi* (Morton, 1834), *Menabites (Delawarella) danei* (Young, 1963), *Reginaites reymenti* Klinger and Kennedy, 1980, *Neogauthiericeras* n. sp. aff. *zafimahovai* Collignon, 1969, *Eubostrychoceras* sp., *Glyptoxoceras* sp., *Baculites* sp. group of *aquilaensis* Reeside, 1927, *Baculites taylorensis* Adkins, 1929, *Scaphites (Scaphites) hippocrepis* (DeKay, 1828) II Cobban, 1969, *Trachyscaphites spiniger spiniger* (Schlüter, 1872), and *Trachyscaphites spiniger porchi* (Adkins, 1929). The position of the Santonian-Campanian boundary in the Gulf Coast, as conventionally defined by ammonites, is significantly lower in the section than the extinction point of the crinoid *Marsupites,* the boundary definition provisionally adopted at the Second International Symposium on Cretaceous Stage Boundaries, 1995, Brussels, Belgium, and significantly lower than the boundary based on nannofloras.

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 ISSN 0003-0082 / Price $5.10

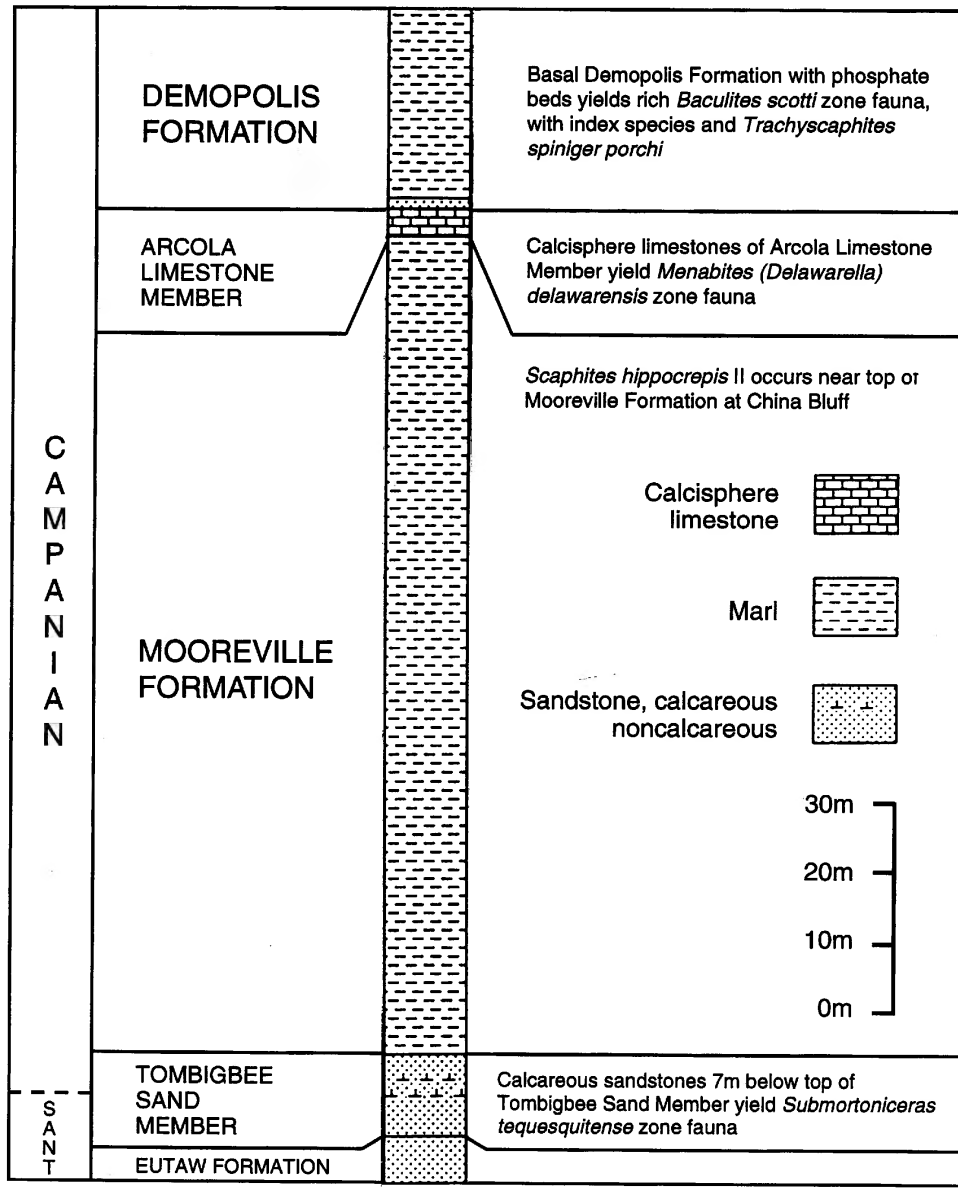


Fig. 1. Generalized stratigraphic sequence in the western part of Alabama and the eastern part of Mississippi, based on the succession at the latitude of Columbus, Mississippi (from information in Dowsett, 1989).

INTRODUCTION

The fossils described in this report come from the Tombigbee Sand Member of the Eutaw Formation, the Mooreville Formation (including the Arcola Limestone Member at the top), and the overlying Demopolis Formation in Mississippi and Alabama (fig. 1). Most of the fossils are from outcrops along the Tombigbee River and were collected by L. W. Stephenson and W. H. Monroe and, more recently, by C. C. Smith and the late N. F. Sohl. Some of these outcrops are now permanently submerged. Reviews of previ-

ous work on this part of the Upper Cretaceous in the Mississippi embayment appeared in Adams et al. (1926), Monroe (1941, 1946), Copeland (1968), Sohl and Smith (1980), and Russell et al. (1982). Dowsett (1989), in particular, presented a readily accessible account of the lithostratigraphy, as well as the ostracod, planktonic foraminiferal, and nannofossil evidence for the age of this sequence. Hancock et al. (1992) also reviewed key foraminiferal data in this sequence.

THE BASE OF THE CAMPANIAN STAGE

The meeting of the Subcommission on Cretaceous Stratigraphy held in Brussels in September, 1995, included discussions aimed at defining the base of the Campanian Stage. There was unanimous support from the Working Party on the Campanian to adopt the extinction point of the crinoid *Marsupites testudinarius* (Schlotheim) as the boundary criterion for the base of the stage. It was further agreed, without a formal vote, that should this criterion be formally adopted by the Commission, a boundary-stratotype should be sought in either Texas or southern England, where this extinction point could be linked to the ranges of species of the crinoid *Uintacrinus* and other groups (Hancock and Gale, 1996). This definition of the base of the Campanian is used here.

SANTONIAN-CAMPANIAN AMMONITE ZONATION

Gulf Coast

Young (1963: 18, table 7) presented a zonation for the Santonian and Campanian of the Gulf Coast region as follows:

Campanian
Hoplitoplacenticeras marroti zone
Delawarella sabinalensis zone
Delawarella delawarensis zone
Submortoniceras tequesquitense zone
Santonian (part)
Texanites shiloensis zone

Young (1963) established a zone of *Delawarella sabinalensis* between the zones of *D. delawarensis* and *Hoplitoplacenticeras marroti.* Subsequent work has shown that *Menabites* (*Delawarella*) *delawarensis* has a very long range in the Gulf Coast (Cobban and Kennedy, 1992a, 1992b), and, therefore, the *delawarensis* zone is here extended to encompass the whole interval between Young's zones of *tequesquitense* and *marroti,* the latter here renamed the *Baculites taylorensis* zone, as discussed below. This modified zonation is as follows:

Baculites taylorensis zone (new term)
Menabites (*Delawarella*) *delawarensis* zone
Submortoniceras tequesquitense zone
Texanites shiloensis zone

Gale et al. (1995) recorded the sequence of crinoids in the Austin Chalk of Texas, and showed that the extinction point of *Marsupites* occurs within the *tequesquitense* zone.

U.S. Western Interior

A much more refined zonation than that in the Gulf Coast exists in the U.S. Western Interior, of which the following zones are relevant to the present discussion:

Campanian (part)
Baculites asperiformis zone
Baculites mclearni zone
Baculites obtusus zone
Baculites sp. (weak flank ribs) zone
Baculites sp. (smooth) zone
Scaphites hippocrepis III zone
Scaphites hippocrepis II zone
Scaphites hippocrepis I zone
Scaphites leei III zone
Santonian (part)
Desmoscaphites bassleri zone
Desmoscaphites erdmanni zone

The *Desmoscaphites bassleri* zone has yielded *Marsupites* at two localities in Montana and Wyoming (Cobban, 1995). The presence of this species provides support for drawing the base of the Campanian between the zones of *D. bassleri* and *S. leei* III. Correlation of ammonite faunas from the Eutaw and Mooreville formations with the zonation in the U.S. Western Interior is discussed further below.

STRATIGRAPHY

Eutaw Formation

The lower part of the Eutaw Formation, below the Tombigbee Sand Member, is as much as 76 m thick in Mississippi and Ala-

bama according to Dowsett (1989) and is an open marine sequence of glauconitic sands and clays. The Tombigbee Sand Member, consisting of massive glauconitic sand, is as much as 30 m thick, and is the uppermost unit of the Eutaw. Kennedy and Cobban (1991) described a rich fauna that occurs as phosphatic molds from about 16 m below the top of this member in excavations on the Tombigbee River near Columbus, Lowndes County, Mississippi. This fauna consists of *Pseudoschloenbachia* (*Pseudoschloenbachia*) *mexicana* (Renz, 1936), *Placenticeras syrtale* (Morton, 1834), *Reginaites leei* (Reeside, 1927), *Reginaites exilis* Kennedy and Cobban, 1991, *Texanites* (*Texanites*) sp. juv. cf. *gallicus* Collignon, 1948, *Texanites* (*Plesiotexanites*) *shiloensis* Young, 1963, Texanitinae incertae sedis, *Hyphantoceras* (?) *amapondense* (van Hoepen, 1921), *Glyptoxoceras* spp., *Boehmoceras arculus* (Morton, 1834), and *Scaphites* (*Scaphites*) *leei* Reeside, 1927, form I Cobban, 1969. This assemblage is referred to the uppermost Santonian *Texanites* (*Plesiotexanites*) *shiloensis* zone of the Gulf Coast sequence, and can be correlated with the upper Santonian *Desmoscaphites erdmanni* zone of the U.S. Western Interior on the basis of the common occurrence of *S.* (*S.*) *leei* I.

Calcareous sandstone layers in the upper part of the Tombigbee Sand Member have yielded large unphosphatized ammonites at a number of localities, the best known being that at Plymouth Bluff on the Tombigbee River in Mississippi (see Stephenson and Monroe, 1940: 73; Dowsett, 1989: fig. 7). A number of authors have discussed the fauna from bed 4 of Stephenson and Monroe at this locality (e.g., Young, 1963), approximately 7 m below the top of the Tombigbee Sand Member. Ammonites from the upper part of the Tombigbee Sand Member at Plymouth Bluff and elsewhere are *Placenticeras syrtale* (Morton, 1834), *Placenticeras placenta* (DeKay, 1828), *Texanites* (*Texanites*) *lonsdalei* Young, 1963, *Texanites* (*Plesiotexanites*) *shiloensis* Young, 1963, *Submortoniceras tequesquitense* Young, 1963, and *Neogauthiericeras* sp. nov. aff. *zafimahovai* Collignon, 1969. *Inoceramus proximus* Tuomey, 1854, is common and was originally described from this locality. This assemblage represents the uppermost Santonian to lowermost Campanian *S. tequesquitense* zone of the Gulf Coast sequence. The late, ornate form of *Marsupites testudinarius* was described from Plymouth Bluff by Springer (1911) as *Marsupites americanus* Springer, 1911. Gale et al. (1995) precisely located this occurrence to a 5 cm interval at the top of bed 4 of Stephenson and Monroe. As in Texas, *M. testudinarius* thus extends well into the *tequesquitense* zone, which is partly or wholly equivalent to the zone of *Scaphites hippocrepis* I in the U.S. Western Interior; this zone has yielded *S. tequesquitense* in Santa Fe County, New Mexico (Cobban and Kennedy, 1991).

Mooreville Formation

There is probably a minor discontinuity between the top of the Eutaw Formation and the base of the Mooreville Formation (Stephenson and Monroe, 1940; Monroe, 1941; Braunstein, 1959; Newton et al., 1959), although this has been disputed (e.g., Dowsett, 1989). The bulk of the Mooreville is blue-gray, slightly micaceous marl, about 50 m thick in Clay County, Mississippi, and 120 m thick in Dallas County, Alabama. *Reginaites reymenti* Klinger and Kennedy, 1980, occurs in the Mooreville Formation 6.1 m above the base at USGS Mesozoic locality 25404, 10.7 km southwest of Montgomery, Montgomery County, Alabama, but does not allow precise dating of this level in the sequence; the genus ranges from the upper Santonian into the lower Campanian elsewhere in the United States.

The upper part of the Mooreville Formation at China Bluff, Sumter County, Alabama, yielded a specimen of *Scaphites* (*Scaphites*) *hippocrepis* DeKay, 1828, form II Cobban, 1969, from 10.7 m above the base of the section, and approximately 17 m below the base of the Arcola Limestone Member. This record indicates the zone of *S. hippocrepis* II of the U.S. Western Interior sequence.

The Arcola Limestone Member at the top of the Mooreville Formation is a distinctive marker, consisting of two beds of calcisphere limestone about 0.6 m thick, separated by 0.75 m of marly chalk in Mississippi. This member expands to 20.8 m in central Ala-

bama (Bottjer, 1980; Frey and Bromley, 1985).

The ammonite fauna in the Arcola Limestone Member consists of *Pachydiscus* (*Pachydiscus*) *paulsoni* (Young, 1963), *Placenticeras placenta* (DeKay, 1828), *Menabites* (*Delawarella*) *delawarensis* (Morton, 1834), *Menabites* (*Delawarella*) *vanuxemi* (Morton, 1830), *Menabites* (*Delawarella*) *danei* Young, 1963, *Eubostrychoceras* sp., *Glyptoxoceras* sp., *Baculites* sp. group of *aquilaensis* Reeside, 1927, and *Trachyscaphites spiniger spiniger* (Schlüter, 1872).

This fauna represents the upper part of the *Menabites* (*Delawarella*) *delawarensis* zone of the Gulf Coast region, where the association of diverse *Menabites* (*Delawarella*) and *Trachyscaphites spiniger spiniger* marks the upper limit of the range of *Menabites* (*Delawarella*) *delawarensis,* well above the disappearance of *Scaphites* (*Scaphites*) *hippocrepis* (DeKay, 1828), form III Cobban, 1969. Correlation with the U.S. Western Interior sequence is more difficult, but the fauna is likely to be equivalent to that of the zone of *Baculites obtusus,* which has yielded *Menabites* (*Delawarella*) *danei* in Colorado (Cobban and Kennedy, 1991).

Demopolis Formation

The Demopolis Formation is divided into a lower unnamed member and an upper Bluffport Marl Member. The lower member consists of approximately 60 m of marl overlain by 60 m of chalk (Dowsett, 1989). Phosphatic nodule beds in the lowest few meters of the Demopolis Formation contain abundant ammonites, most of which are fragments of *Baculites taylorensis* Adkins, 1929; also present are *Pachydiscus* (*Pachydiscus*) aff. *travisi* Adkins, 1929, *Hoplitoplacenticeras* (*Hoplitoplacenticeras*) sp., *Menabites* (*Delawarella*) *vanuxemi,* and *Trachyscaphites spiniger* (Schlüter, 1872) *porchi* Adkins, 1929.

The bulk of this assemblage appears to postdate the *M.* (*D.*) *delawarensis* zone of the Gulf Coast sequence, corresponding to Young's (1963) *H.* (*H.*) *marroti* zone. So few specimens of *H.* (*H.*) *marroti* are known from the Gulf Coast that we propose a zone of *Baculites taylorensis* for this interval, which can also be recognized in phosphatic faunas of the Pecan Gap Chalk in central and northeast Texas (Cobban and Kennedy, 1994) and in the basal phosphate bed of the Annona Chalk in Hempstead and Howard counties, Arkansas (Kennedy and Cobban, 1993a, 1993b). *Trachyscaphites spiniger porchi* occurs in the zones of *Baculites mclearni* and *B. asperiformis* in the U.S. Western Interior.

DISCUSSION

The ammonite faunas from the Eutaw and Mooreville Formations in Mississippi and Alabama span the Santonian-Campanian boundary in ammonite terms, and occur in a sequence that matches the record in Texas and Arkansas in the Gulf Coast region, as well as that in the U.S. Western Interior. Following the microfaunal and nannofloral study of Dowsett (1989) on the same sequence, it is possible to correlate zonal schemes and stage boundaries based on ostracods, planktonic forams, nannofossils, and ammonites, as shown in Figure 2.

The base of the Campanian, defined as the extinction point of *Marsupites testudinarius,* falls within the "Santonian" of Dowsett's micro- and nannofossil standard—within the *Dicarinella asymmetrica* planktonic foraminiferal zone, the *Calculites obscurus* nannofossil zone, and the *Alatacythera cheethami* ostracod zone—as currently used in the Gulf Coast. It is above the base of the *Submortoniceras tequesquitense* zone, previously taken to correspond to the base of the Campanian in terms of ammonites (e.g., Young, 1963).

LOCALITIES WHERE FOSSILS WERE COLLECTED

USGS Mesozoic locality **282.** Tombigbee Sand Member, Columbus, Lowndes County, Mississippi. Collected by L. C. Johnson. *Placenticeras syrtale, Texanites lonsdalei, Submortoniceras tequesquitense, Submortoniceras* sp., *Inoceramus proximus.*

USGS Mesozoic locality **6916.** Eutaw Formation, Plymouth Bluff, Tombigbee River, Lowndes County, Mississippi, layer 4 of section. Collected by L. W. Stephenson. *Placenticeras syrtale, P. placenta,* indeterminate texanitid.

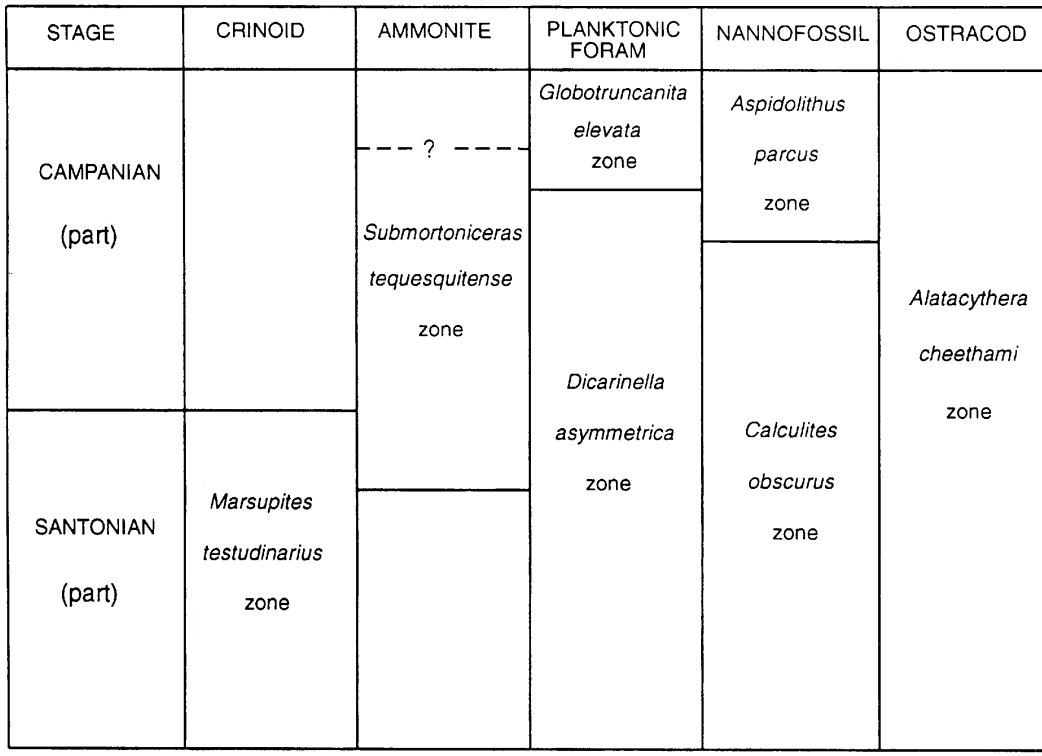


Fig. 2. Correlation of planktonic foraminiferal, nannofossil, and ostracod zones in the study area, based on data from Plymouth Bluff, Mississippi in Dowsett (1989), who placed the Santonian-Campanian boundary at the base of the *Aspidolithus parcus* nannofossil zone. The boundary definition used herein is that adopted provisionally at the 1995 Brussels Meeting of the Subcommission on Cretaceous Stratigraphy: the extinction point of the crinoid *Marsupites testudinarius* (Hancock and Gale, 1996).

USGS Mesozoic locality **6925.** Eutaw Formation, bluff below railroad bridge at Aberdeen, Monroe County, Mississippi. Collected by L. W. Stephenson. *Plesiotexanites shiloensis, Placenticeras syrtale.*

USGS Mesozoic locality **17202.** Plymouth Bluff, Tombigbee River, Lowndes County, Mississippi, about 7.62 m (25 ft) below base of Selma Chalk. Collected by L. W. Stephenson and W. H. Monroe. *Placenticeras syrtale.*

USGS Mesozoic locality **25404.** Mooreville Formation, 6.1 m (20 ft) above base, 10.7 km (6.5 mi.) southwest of Montgomery, SW ¼ NW ¼ sec. 26, T26 N, R17 E, Montgomery County, Alabama. Collected by H. L. Reade. *Reginaites reymenti.*

USGS Mesozoic locality **25465.** Arcola Limestone Member, roadcuts at Hacoth Hill, NE ¼ sec. 5, T20 N, R1E, Greene County, Alabama. Collected by N. F. Sohl. *Baculites* group of *aquilaensis, Glyptoxoceras* sp.

USGS Mesozoic locality **25496.** Eutaw Formation, Tombigbee Sand Member, Plymouth Bluff, Tombigbee River, Lowndes County, Mississippi. Collected by L. W. Stephenson. *Placenticeras placenta, Placenticeras syrtale, Submortoniceras tequesquitense.*

USGS Mesozoic locality **30687.** Arcola Limestone Member at intersection of State Route 22 and the Beloit-Cahaba road, NE ¼ NW ¼ sec. 23, T16N, R9E, Dallas County, Alabama. Collected by N. F. Sohl. *Menabites (Delawarella) danei.*

USGS Mesozoic locality **31359.** Base of Demopolis Formation, left bank of Alabama River at Hatchers Bluff on Blackwells Bend, E ½ sec. 36, T16N, R10E, Dallas County, Alabama. Collected by N. F. Sohl, C. C. Smith, and J. Reinhardt. *Trachyscaphites spiniger porchi.*

USGS Mesozoic locality **31433.** Arcola

Limestone Member, southwest bank of Tombigbee River, just north of entrance to Noxubee River at mileage 281.4, Sumter County, Alabama. Collected by N. F. Sohl and C. C. Smith. *Placenticeras* sp., *Menabites* (*Delawarella*) sp. juv., *Glyptoxoceras* sp.

USGS Mesozoic locality **31447.** Upper part of Mooreville Formation, about 10.7 m (35 ft) above base of section on right bank of Tombigbee River at China Bluff about 2 km (1.2 mi.) below Warsaw, NE ¼ NE ¼, sec. 5, T22N, R2W, Sumter County, Alabama. Collected by N. F. Sohl and C. C. Smith. *Scaphites* (*Scaphites*) *hippocrepis* II.

USGS Mesozoic locality **31450.** Arcola Limestone Member, right bank of Tombigbee River at China Bluff, about 2 km (1.2 mi.) below Warsaw, NE ¼ NE ¼ sec. 5, T22N, R2W, Sumter County, Alabama. Collected by N. F. Sohl and C. C. Smith. *Placenticeras* sp., *Menabites* (*Delawarella*) *delawarensis.*

USGS Mesozoic locality **31472.** Eutaw Formation, Tombigbee Sand Member, Plymouth Bluff, Lowndes County, Alabama, from prominent sandstone bed of unit 4. Collected by N. F. Sohl and C. C. Smith. *Placenticeras syrtale, Texanites* (*Texanites*) *lonsdalei, Submortoniceras tequesquitense.*

USGS Mesozoic locality **31485.** Arcola Limestone Member, road cut along west side of Route 19 about 100 yards northwest of St. Luke's Church and cemetery, NW ¼ sec. 5, T2ON, R1E, Greene County, Alabama. Collected by C. C. Smith. *Glyptoxoceras* sp.

USGS Mesozoic locality **31515.** Arcola Limestone Member, left bank of Tombigbee River at Fitzpatrick Landing at mileage 230 by river marker at section line between secs. 14 and 15, T19N, R23E, Sumter County, Alabama. Collected by N. F. Sohl and W. A. Bryant. *Glyptoxoceras* sp.

USGS Mesozoic locality **31530.** Arcola Limestone Member, bluffs along right bank of Tombigbee River at mileage 267.75, sec. 29, T21N, R1W, Sumter County, Alabama. Collected by N. F. Sohl, W. A. Bryant, and D. J. Bottjer. *Pachydiscus* sp., *Placenticeras placenta, Menabites* (*Delawarella*) *danei, Glyptoxoceras* sp., *Baculites* group of *aquilaensis.*

USGS Mesozoic locality **31532.** Demopolis Formation, zone of phosphatic nodules 60 cm above top of Arcola Limestone Member, sec. 29, T21N, R1W, Sumter County, Alabama. Collected by N. F. Sohl, W. A. Bryant, and D. J. Bottjer. *Placenticeras* sp., indeterminate texanitid, *Baculites taylorensis, Trachyscaphites spiniger porchi.*

USGS Mesozoic locality **31557.** Arcola Limestone Member, right bank of Tombigbee River immediately above mouth of Noxubee River at mileage 281.5, NW ¼ sec. 3, T21N, R2W, Sumter County, Alabama. Collected by N. F. Sohl, C. C. Smith, and W. A. Bryant. *Placenticeras placenta, Menabites* (*Delawarella*) *danei, M.* (*D.*) *delawarensis, Glyptoxoceras* sp., *Baculites* group of *aquilaensis.*

USGS Mesozoic locality **31558.** Demopolis Formation, lower phosphatic nodule zone, 60 cm above Arcola Limestone Member, right bank of Tombigbee River immediately above mouth of Noxubee River at mileage 281.5, NW ¼ sec. 3, T21N, R2W, Sumter County, Alabama. Collected by C. C. Smith, N. F. Sohl, and W. A. Bryant. Phosphatic *Baculites* sp.

USGS Mesozoic locality **31561.** Demopolis Formation, lower phosphatic nodule zone, left bank of Noxubee River immediately upstream of mouth of river and bridge to county road 85, SE ¼ NW ¼ sec. 3, T21N, R2W, Sumter County, Alabama. Collected by N. F. Sohl, C. C. Smith, and W. A. Bryant. Phosphatic *Pachydiscus* (*P.*) aff. *travisi, Hoplitoplacenticeras* sp., *Baculites taylorensis.*

USGS Mesozoic locality **31562.** Demopolis Formation, locality and collectors as for 31561, but from upper zone of phosphatic nodules. Phosphatic *Pachydiscus* sp., *Baculites* sp.

USGS Mesozoic locality **31592.** Upper phosphatic nodule zone in Demopolis Formation, bluffs on right bank of Tombigbee River at mileage 267.75, sec. 29, T21N, R1W, Sumter County, Alabama. Collected by N. F. Sohl. Phosphatic *Pachydiscus* (*P.*) aff. *travisi, Baculites* sp.

USGS Mesozoic locality **32112.** Eutaw Formation, Plymouth Bluff, unit 4 of section. Collected by C. C. Smith. *Placenticeras syrtale, Texanites lonsdalei, Texanites* sp., *Submortoniceras tequesquitense, Inoceramus proximus.*

USGS Mesozoic locality **32145.** Eutaw Formation, Tibbee Creek, NE ¼, sec. 10,

T19N, R17E, Lowndes County, Alabama. Collected by C. C. Smith. *Placenticeras syrtale, Texanites (Texanites) lonsdalei, Submortoniceras* sp.

USGS Mesozoic locality **32146.** Tombigbee Sand Member of Eutaw Formation, right bank of Tibbee Creek at midpoint of the northern line of SE ¼ sec. 4, T19N, R17E, Lowndes County, Mississippi. Collected by C. C. Smith. *Neogauthiericeras* aff. *zafimahovai.*

USGS Mesozoic locality **32942.** Arcola Limestone Member of Mooreville Formation at Arcola Landing on Warrior River, sec. 4, T18N, R3E, Hale County, Alabama. Collected by C. C. Smith. *Baculites taylorensis.*

USGS Mesozoic locality **32954.** Arcola Limestone Member, right bank of Tombigbee River, just north of mouth of Noxubee River at mileage 281.4, Sumter County, Alabama. Collected by C. C. Smith. *Pachydiscus (Pachydiscus) paulsoni.*

USGS Mesozoic locality **32956.** Float from Arcola Limestone, right bank of Tombigbee River, just north of mouth of Noxubee River, Sumter County, Alabama. Collected by C. C. Smith. Phosphatic *Pachydiscus (Pachydiscus)* aff. *travisi, Baculites taylorensis, Trachyscaphites spiniger porchi.*

USGS Mesozoic locality **33032.** Mooreville Formation, Tibbee Creek, east of center sec. 10, T15S, R17E, Clay County, Mississippi. Collected by C. C. Smith. *Menabites (Delawarella) danei, Eutrephoceras* sp.

USGS Mesozoic locality **33296.** Top of lowermost limestone bed of Arcola Limestone Member, bluffs on right side of Tombigbee River at Swilley's bend, 442 km (267.75 mi.) above Mobile in middle east edge of sec. 29, T21N, R1W, Sumter County, Alabama. Collected by C. C. Smith. *Trachyscaphites spiniger spiniger.*

USGS Mesozoic locality **36688.** Base of Demopolis Formation, Beloit, Dallas County, Alabama. Collected by C. C. Smith. Phosphatic *Pachydiscus* sp., *Placenticeras* sp., *Baculites taylorensis.*

REPOSITORY OF SPECIMENS

Specimens mentioned in the text have been assigned USNM numbers and deposited in the collections of the U.S. National Museum of Natural History in Washington, D.C. Other specimens are reposited in the Texas Memorial Museum, Austin (TMM-UT).

CONVENTIONS

The suture terminology is that of Kullmann and Wiedmann (1970), with E = external lobe, L = lateral lobe, U = umbilical lobe, and I = internal lobe. Whorl dimensions are expressed in millimeters; D = diameter, Wb = whorl breadth, Wh = whorl height, and U = umbilical diameter. The term "rib index," as applied to heteromorphs, is the number of ribs occupying a distance equal to the whorl height at the midpoint of the interval counted. Arrows on photographs indicate the adapical end of the body chamber, where preserved. Specimens are photographed in the conventional position with the aperture on top, although the authors recognize that the animals would have been oriented differently in life.

SYSTEMATIC PALEONTOLOGY

ORDER AMMONOIDEA ZITTEL, 1884

SUPERFAMILY DESMOCERATACEAE ZITTEL, 1895

FAMILY PACHYDISCIDAE SPATH, 1922

Genus and Subgenus *Pachydiscus* Zittel, 1884

TYPE SPECIES: *Ammonites neubergicus* von Hauer, 1858: 12, pl. 2, figs. 1–3; pl. 3, figs. 1, 2, by subsequent designation of de Grossouvre (1894: 177).

Pachydiscus (Pachydiscus) aff. *travisi* (Adkins, 1929)

Figure 3A–F

Compare:

Parapachydiscus travisi Adkins, 1929: 207, pl. 6, figs. 7–9.

DESCRIPTION: There are 12 phosphatic fragments with whorl heights of as much as 37 mm. Juveniles are moderately evolute, with the umbilicus comprising approximately 25% of diameter. The umbilicus is moderately deep, the umbilical wall is inclined outward, and the umbilical shoulder is broadly

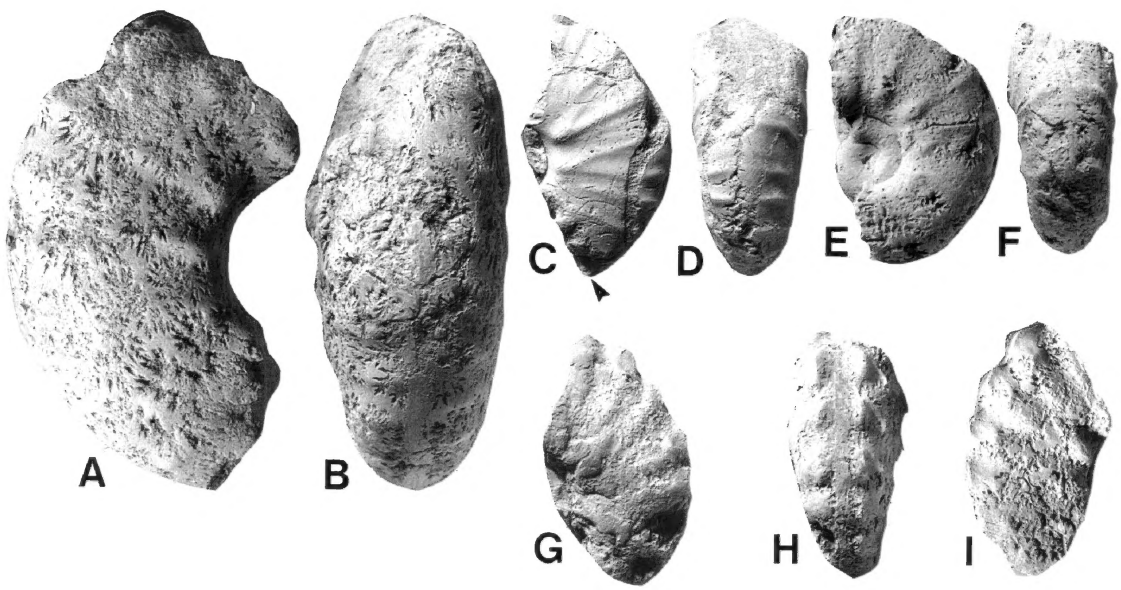


Fig. 3. **A–F.** *Pachydiscus* (*Pachydiscus*) aff. *travisi* (Adkins, 1929). **A, B.** USNM 486644, USGS Mesozoic locality 31561; **C, D.** USNM 486642, USGS Mesozoic locality 31561; **E, F.** USNM 486643, USGS Mesozoic locality 31592. **G–I.** *Hoplitoplacenticeras* (*Hoplitoplacenticeras*) sp. USNM 486652, USGS Mesozoic locality 31561. All specimens are phosphatic internal molds from the base of the Demopolis Formation, Campanian, *Baculites taylorensis* zone. All figures are ×1.

rounded. The inner flanks are flattened and the ventrolateral shoulder and venter are broadly rounded. At a diameter of approximately 35 mm there are eight strong, distant umbilical bullae per whorl. These give rise to strong, straight, prorsiradiate ribs, either singly or in pairs, with sparser, shorter, intercalated ribs between. All ribs flex forward over the ventrolateral shoulder, and strengthen markedly on the ventrolateral area; they are feebly convex and efface over the midventral region. This pattern of ornament appears on the largest fragment, with a whorl height of 38 mm, and a ratio of whorl breadth to whorl height of 0.9.

DISCUSSION: The pattern of ribbing, presence of umbilical bullae, strengthening of ribs on the ventrolateral shoulder, and marked weakening of ribs over the midventral region are features shared with *P.* (*P.*) *travisi* (Adkins, 1929) (p. 207, pl. 6, figs. 7–9), from the Pecan Gap Chalk of northeast and central Texas. The type and other material of *P.* (*P.*) *travisi* that we have studied (Cobban and Kennedy, 1994: D3, pl. 1, figs. 1–15; pl. 2, figs. 9–11; text-fig. 4) are invariably more compressed and have weaker ribbing, which generally effaces at midflank, and weaker ventrolateral ornament. Therefore, we refer the present material to *P.* (*P.*) aff. *travisi.*

OCCURRENCE: Campanian, *Baculites taylorensis* zone, phosphatic beds in lower part of the Demopolis Chalk at USGS Mesozoic localities 31532, 31561, and 31592.

Pachydiscus (*Pachydiscus*) *paulsoni* (Young, 1963)

Parapuzosia paulsoni Young, 1963: 53, pl. 11, figs. 3–5; pl. 12, figs. 1–4; pl. 15, fig. 10; pl. 17, fig. 9; pl. 19, figs. 3, 4; text-figs. 8a, b, 9g, j, r.

Pachydiscus (*Pachydiscus*) *paulsoni* (Young, 1963). Cobban and Kennedy, 1992a: 69, pl. 1, figs. 4–7; pl. 4, figs. 7–9; pl. 5, figs. 7, 8; text-figs. 3a–c, 4b.

TYPE: The holotype is TMM-UT 30625 from the Gober Chalk in McCurtain County, Oklahoma.

DISCUSSION: USNM 486645 (not figured) is a fragment with a maximum preserved whorl height of 61 mm. Although crushed, it shows the characteristic, narrow, flexuous prorsiradiate ribs of *P.* (*P.*) *paulsoni.*

OCCURRENCE: Campanian, *M. (D.) delawarensis* zone, Arcola Limestone Member at USGS Mesozoic locality 32954. This species also occurs in the *Submortoniceras tequesquitense* zone in the lower Campanian Austin Chalk, Travis County, Texas; *M. (D.) delawarensis* zone in McCurtain County, Oklahoma, and Little River County, Arkansas, in equivalents of the Gober Chalk; lower Campanian, Roxton Limestone Member at the top of the Gober Chalk in Lamar County, Texas; and middle Campanian Ozan Formation in Fannin County, Texas.

SUPERFAMILY HOPLITACEAE H. DOUVILLÉ, 1890

FAMILY PLACENTICERATIDAE HYATT, 1900

Genus *Placenticeras* Meek, 1876

TYPE SPECIES: *Ammonites placenta* DeKay, 1828: 278, pl. 5, fig. 3(2), by original designation of Meek, 1876: 426.

Placenticeras placenta (DeKay, 1828)
Figures 4–6

Ammonites placenta DeKay, 1828: 278, pl. 5, fig. 2 (not 5).

Placenticeras placenta (DeKay, 1828). Kennedy and Cobban, 1993c: 834, figs. 5.7, 5.8, 6.1, 6.2, 9.14–9.16 (with synonymy).

Placenticeras placenta (DeKay, 1828). Kennedy et al., 1995: pl. 2, figs. 11, 12; pl. 4, figs. 21, 22.

TYPE: DeKay's specimen is lost; it was from the Chesapeake and Delaware Canal, Delaware.

DESCRIPTION: The six specimens in the present collections range from 90 to 220 mm in diameter. The smallest specimen, USNM 486646 (not figured), from the Arcola Limestone Member, is very involute, with the umbilicus comprising 15% of diameter. The umbilical wall is flat and inclined outward, producing a craterlike umbilicus, with a narrowly rounded to sharp umbilical shoulder. The inner flanks are broadly rounded and the outer flanks are flattened and convergent. The venter is very narrow and sulcate, with sharp edges. There is no ornament.

USNM 486647 (fig. 4) is 220 mm in diameter, with U = 14% of diameter. This specimen retains a narrow, sulcate venter, with sharp ventrolateral shoulders throughout, and lacks ornament; it appears to be a juvenile macroconch.

What may be an adult microconch is represented by USNM 486648 (fig. 5), an estimated 180 mm in diameter, with U = 18% of diameter. This specimen has faint, distant umbilical bullae and traces of flank ribs at the smallest diameter observed, but is smooth thereafter. The venter is markedly sulcate with sharp ventrolateral shoulders to a diameter of 120 mm, beyond which the venter flattens and broadens and the ventrolateral shoulders become progressively less distinct.

DISCUSSION: Large size, a compressed whorl section, a narrow, sulcate venter when young, and lack of or weak ornament, distinguish these specimens from *Placenticeras syrtale* (Morton, 1834), discussed below. *Placenticeras meeki* Böhm, 1898 (p. 200, footnote; see Stephenson, 1941: 431, pl. 91, fig. 1; pl. 92) appears in the Gulf Coast at a much higher horizon than the present material. It differs in being more compressed and having a much more incised suture with narrow-stemmed saddles.

OCCURRENCE: The provenance of the missing type is unknown, but the species occurs in the Merchantville, Marshalltown, and Wenonah Formations in New Jersey and Delaware; in North Carolina; in the uppermost Santonian and lowermost Campanian *S. tequesquitense* zone of the Tombigbee Sand Member of the Eutaw Formation and in the Campanian *M. (D.) delawarensis* zone of the Arcola Limestone Member in Mississippi; and in the Gober Chalk and Ozan Formation in northeast Texas.

Placenticeras syrtale (Morton, 1834)
Figures 7, 8

Ammonites syrtalis Morton, 1834: 40, pl. 16, fig. 4.

Stantonoceras pseudocostatum Johnson. Scott and Cobban, 1964: pl. 8.

Placenticeras syrtale (Morton, 1834). Wolleben, 1967: 1161 (with additional synonymy).

Placenticeras syrtale syrtale (Morton, 1834). Wolleben, 1967: 1161, pl. 150, fig. 5; pl. 151, figs. 1, 2, 5–7; text-fig. 7e, f.

Placenticeras syrtale adkinisi Wolleben, 1967: 1164, pl. 151, figs. 8, 9; pl. 152, figs. 1, 2, 5–8; text-fig. 8g.

Placenticeras syrtale rooneyi Wolleben, 1967: 1164, figs. 6, 7; pl. 151, figs. 3, 4; pl. 152, figs. 3, 4; text-fig. 7d, g.

Fig. 4. *Placenticeras placenta* (DeKay, 1828). USNM 486647, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone, Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 25496. Figure is ×0.7 (actual diameter = 220 mm).

Placenticeras (*Stantonoceras*) *guadalupae* Roemer. Cobban, 1976: 125, pl. 2, fig. 7.
Placenticeras syrtale (Morton, 1834). Kennedy et al., 1995: pl. 2, figs. 1, 2.

TYPE: The holotype, by monotypy, is the original of Morton (1834: 40, pl. 16, fig. 4) from the "older Cretaceous" of Greene County, Alabama. It was refigured by Hyatt (1903, pl. 27, fig. 15; pl. 28, figs. 1, 2) and is no. 282 in the collection of the Academy of Natural Sciences of Philadelphia.

DESCRIPTION: The 18 specimens range up to 140 mm in diameter (table 1). Coiling is moderately involute, with U = 20% of diameter. The umbilicus is shallow, with a rounded umbilical wall that is inclined outward and merges imperceptibly with the broadly rounded flanks. The ventrolateral

Fig. 5. *Placenticeras placenta* (DeKay, 1828). USNM 486648, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone, Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 6916. Figure is ×1.

Fig. 6. *Placenticeras placenta* (DeKay, 1828). USNM 486648, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone, Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 6916. Figure is ×1.

TABLE 1
Dimensions (mm) of *Placenticeras syrtale* (Morton, 1834)[a]

USNM specimen	D	Wh	U
486649	118.0	56.5 (49.9)	22.5 (19.1)
486651	130.5	59.0 (45.4)	26.0 (20.0)
486650	135.0	60.5 (44.8)	28.0 (20.7)

[a]Figures in parentheses are percentages of diameter; D = diameter; Wh = whorl height; U = umbilical diameter.

shoulders are sharp, with a narrow tabulate venter on the phragmocone, which broadens and rounds progressively toward the adapertural end of the adult body chamber. The whorl section is compressed, with the ratio of whorl breadth to whorl height averaging approximately 0.67 in costal section; the greatest breadth is at the umbilicolateral bullae, and below midflank intercostally.

Juvenile phragmocones are ornamented by weak to strong conical bullae, about eight per whorl, lying just outside the umbilical shoulder at the smallest diameter observed, and migrating out to an inner flank position as size increases. These bullae give rise to pairs of low, broad, flexuous ribs that are convex across the midflank and concave on the outer flank, where additional crescentic outer flank ribs are inserted. All ribs sweep forward over the outermost flank, and develop small, outer lateral tubercles. Small ventrolateral clavi, two or three times as numerous as the outer lateral tubercles, occur obliquely on sharp ventrolateral shoulders, alternating in position across the narrow, tabulate venter. As size increases, outward migration and strengthening of the umbilical bullae are accompanied by coarsening of the flank ribs, modification of the outer lateral tubercles into coarse bullae two to three times as numerous as the umbilical bullae, effacement of the ventrolateral clavi, blunting of the ventrolateral shoulders, and broadening of the venter. What seem to be adult body chambers show uncoiling of the umbilical seam, weakening of the outer lateral tubercles, and broadening of the venter. These specimens are the same diameter as those retaining juvenile ornament. The latter we presume to be

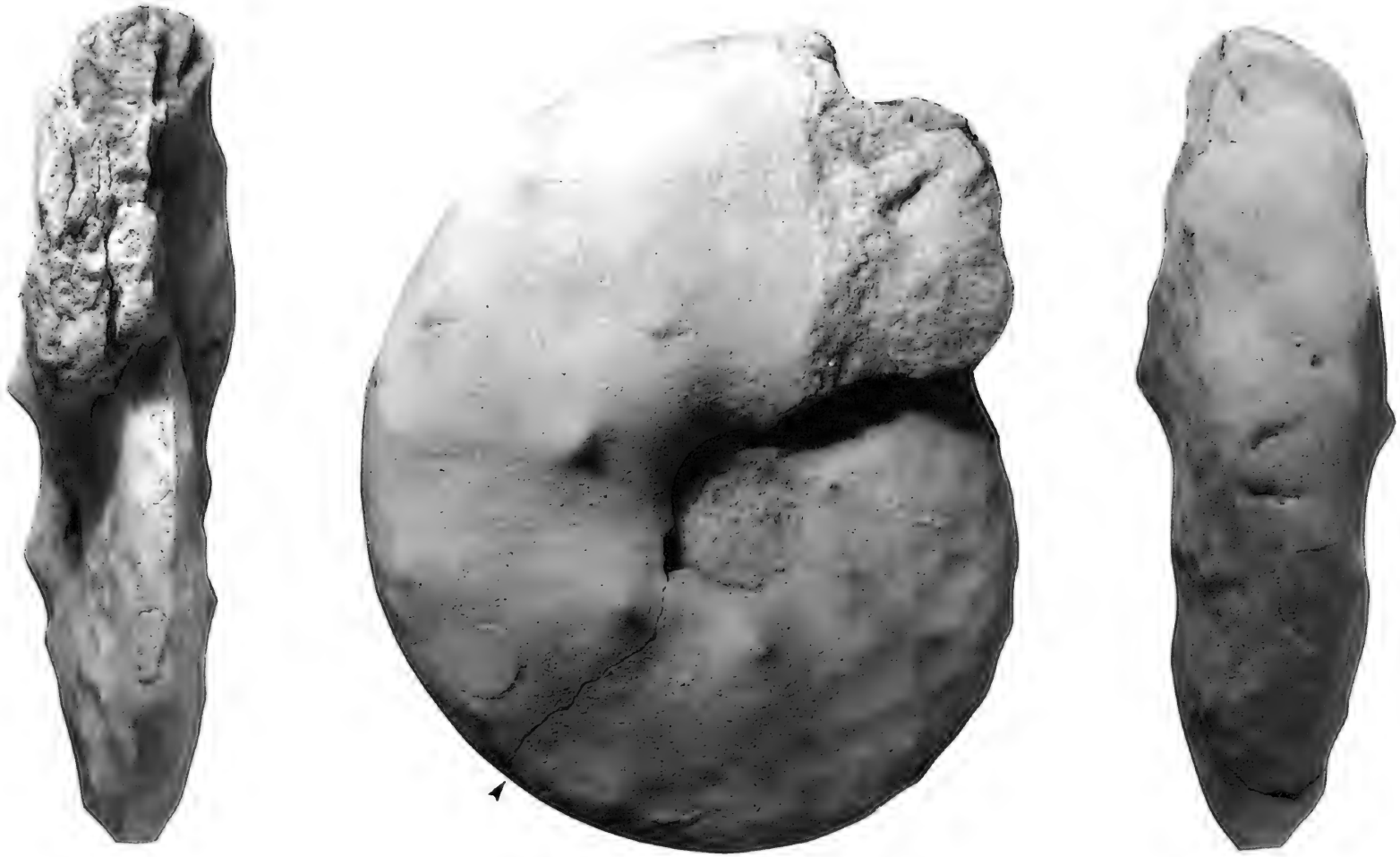


Fig. 7. *Placenticeras syrtale* (Morton, 1834). USNM 486649, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone, Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 6916. Figures are ×1.

juvenile macroconchs, the former, adult microconchs.

DISCUSSION: Wolleben (1967) analyzed temporal changes in *Placenticeras* from the San Carlos and Ojinaga Formations of Presidio County in Trans-Pecos Texas, and Chihuahua, Mexico. He recognized three successive subspecies: *P. syrtale syrtale* (Morton, 1834) of the upper Santonian and lower Campanian; *P. syrtale adkinsi* Wolleben, 1967, of the lower Campanian, a subspecies in which specimens corresponding to *Placenticeras pseudosyrtale* Hyatt, 1903, of previous authors are abundant; and *P. syrtale rooneyi* Wolleben, 1967, the youngest subspecies (of the higher lower Campanian) in which specimens corresponding to *Placenticeras newberryi* Hyatt, 1903 are abundant. His approach ignores the rules of priority, and *rooneyi* and *adkinsi* are both synonyms of previously named species. However, his analysis allows the present material to be placed in sequence; it falls between his *P. syrtale syrtale* and *P. syrtale adkinsi.*

Compared with other species, *P. syrtale* is most similar to the European *Placenticeras polyopsis* (Dujardin, 1837) (see revision in Kennedy and Wright, 1983: 856, pls. 86–88; text-figs. 1–4). However, *P. syrtale* lacks the distinctive delicate ribbing of the inner whorls, which characterizes *P. polyopsis,* and its bullae remain on the umbilical shoulder or inner flank, rather than migrating to an outer lateral position during later growth stages; there are also ten rather that eight lobes in the adult suture of *P. syrtale.*

OCCURRENCE: The present specimens are from the uppermost Santonian and lowermost Campanian *S. tequesquitense* zone, Tombigbee Sand Member of the Eutaw Formation at USGS Mesozoic localities 282, 6916, 6925, 25496, 32112, and 32145. The species ranges from the upper Santonian to lower Campanian, and is known from northern Mexico, Texas, Alabama, Mississippi, New Mexico, Colorado, Wyoming, Montana, and Utah.

Genus and subgenus *Hoplitoplacenticeras* (*Hoplitoplacenticeras*) Paulcke, 1907

TYPE SPECIES: *Hoplites-Placenticeras plasticus* Paulcke, 1907: 186; ICZN Opinion 555, 1959, name no. 1629.

Hoplitoplacenticeras (*Hoplitoplacenticeras*) sp.

Figure 3G–I

DESCRIPTION: Our only specimen is a completely septate fragment with a maximum preserved whorl height of 18 mm. Coiling is moderately involute, with a small, deep umbilicus; the umbilical wall is flattened and inclined outward and the umbilical shoulder is broadly rounded. The inner flanks are broadly rounded, the outer flanks are flattened and convergent, the ventrolateral shoulders are broadly rounded, and the venter is flattened. The overall whorl section is trapezoidal, with an intercostal whorl breadth to whorl height ratio of 0.60 and a costal ratio of 0.51. Distant primary ribs arise at the umbilical seam and strengthen across the umbilical wall, developing into strong, sharp bullae perched on the umbilical shoulder. These give rise to pairs of strong ribs that are straight and prorsiradiate, broadening and strengthening across the flanks. Ribs develop weak inner ventrolateral clavi connected to much stronger, compressed outer ventrolateral clavi, each of which is linked across the venter by a low, broad rib.

DISCUSSION: This fragment is more sparsely ribbed and more coarsely tuberculate than *H. (H.) marroti* (Coquand, 1859) (see revision in Kennedy, 1986: 70, pl. 2, figs. 3, 4; pl. 9, figs. 1–8, 11, 12; pl. 10, figs. 1–12; pl. 12, figs. 1, 2). It is closer to specimens from the Roxton Member at the top of the Gober Chalk of Lamar County, Texas, which were compared to *H. (H.) plasticum* (Paulcke, 1907) (Cobban and Kennedy, 1992b), but our specimen is too poor for specific determination.

OCCURRENCE: Campanian, *Baculites taylorensis* zone, phosphate bed in the lower part of the Demopolis Formation at USGS Mesozoic locality 31561.

SUPERFAMILY ACANTHOCERATACEAE DE GROSSOUVRE, 1894

FAMILY COLLIGNONICERATIDAE WRIGHT AND WRIGHT, 1951

SUBFAMILY TEXANITINAE COLLIGNON, 1948

Genus and Subgenus *Texanites* (*Texanites*) Spath, 1932

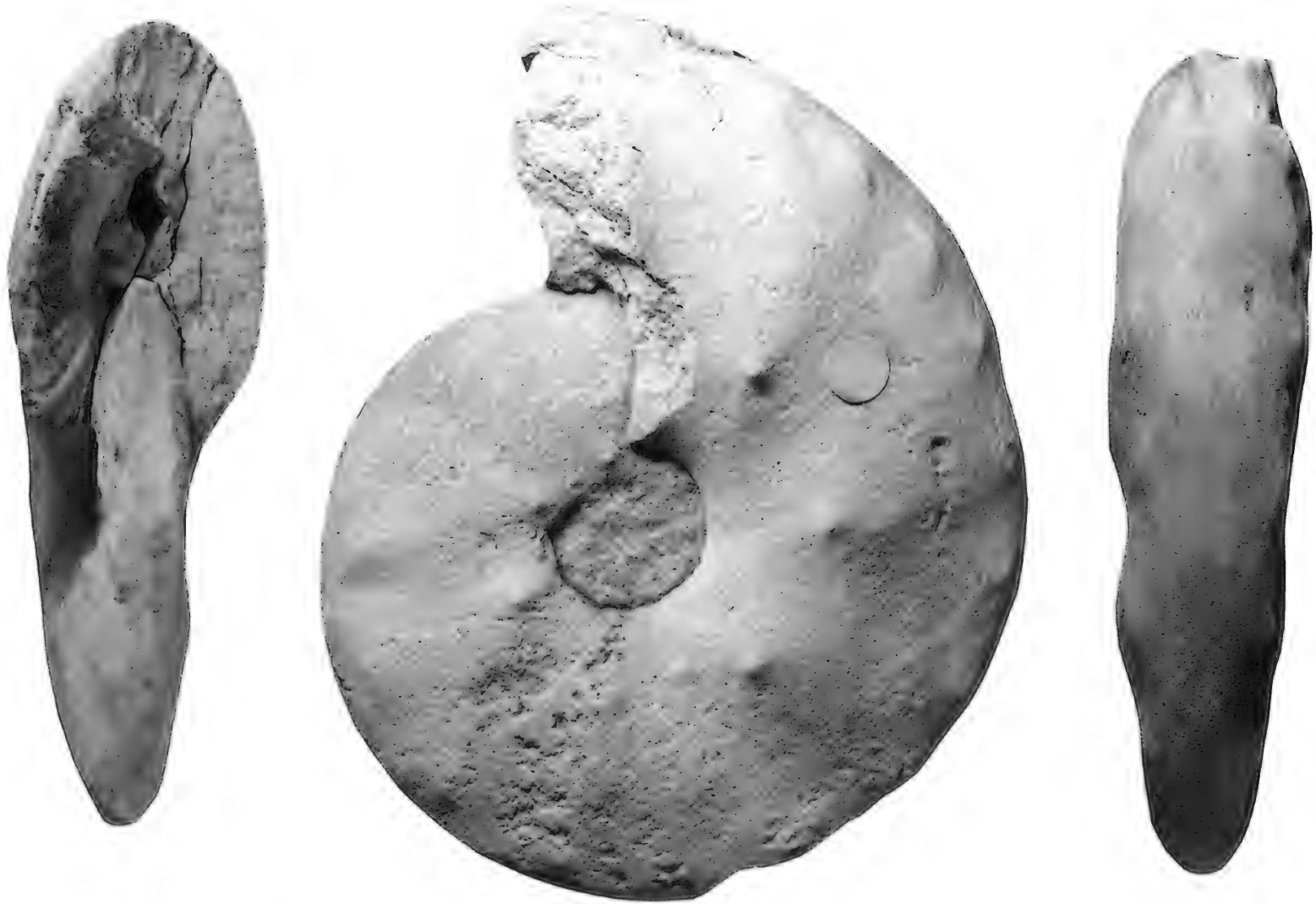


Fig. 8. *Placenticeras syrtale* (Morton, 1834). USNM 486651, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone, Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 17202. Figures are ×1.

Texanites (Texanites) lonsdalei Young, 1963
Figures 9–12

Texanites (Texanites) lonsdalei Young, 1963: 90, pl. 34, fig. 1; pl. 51, figs. 3–7; pl. 58, figs. 5, 6; text-figs. 22a, d.

TYPE: The holotype is TMM-UT 30474, the original of Young (1963: 90, pl. 34, fig. 1; pl. 51, figs. 3–7; pl. 58, figs. 5, 6; text-figs. 22a, d) from the Dessau Chalk of Kitchens Ranch, Travis County, Texas.

DESCRIPTION: There are 14 specimens in the present collections. USNM 486653 (fig. 9) is a crushed juvenile 135 mm in diameter. Coiling is evolute, with U = 37% of diameter. There are 23 or 24 coarse, distant ribs that arise on the umbilical wall and strengthen into pinched bullae that project into the umbilicus. These bullae give rise to coarse, blunt, straight prorsiradiate ribs that are narrower than the interspaces between them. There is a row of strong, lateral tubercles a little dorsal of midflank and widely separated from the umbilical row of bullae, and a similar distance from a submarginal row of slightly weaker, rounded to feebly clavate tubercles, which is close to a marginal row of much larger, coarse clavi. There are also 26 external clavi per whorl. Although crushed, there is evidence of a broad, smooth zone separating the strong external clavi from a strong siphonal keel.

USNM 486654 (figs. 10, 11) is 195 mm in diameter; coiling is evolute, with U = 35% of diameter; the umbilicus is moderately deep with a rounded undercut wall. The whorl section is compressed oval in intercostal section, with a ratio of whorl breadth to whorl height of 0.70, and compressed polygonal in costal section, with a ratio of whorl breadth to whorl height of 0.82; the greatest breadth is at the lateral tubercles. There are 24 broad primary ribs that arise at the umbilical seam, strengthen and sweep backward on the umbilical wall, and develop into prominent, sharp umbilical bullae. These bullae give rise to coarse, rounded ribs that are straight, prorsiradiate, and narrower than the interspaces between them. Strong, feebly bullate, subspinose lateral tubercles are widely separated from the umbilical row of bullae, and equally widely separated from a much weaker, submarginal row of tubercles, which is close to a much stronger marginal row of clavi. The marginal and external clavi number 33–36 on the last whorl. A broad, smooth zone separates the external clavi from a strong, blunt siphonal keel.

USNM 486655 (fig. 12) is part of an adult body chamber with a maximum preserved whorl height of 102 mm, representing just over one-third of a whorl. There are 12 strong, pinched bullae on the umbilical shoulder, separated by wider interspaces between them. These bullae give rise to broad, low, blunt, straight prorsiradiate ribs, with feeble, effacing midlateral tubercles, weak submarginal tubercles, and stronger, persistent marginal and external clavi.

DISCUSSION: *Texanites (T.) lonsdalei* is easily separated from *Texanites (T.) texanus texanus* (Roemer, 1852) (pl. 3, fig. 1; see Young, 1963: 80, pl. 38, figs. 1, 2; pl. 40, figs. 1–3; pl. 41, fig. 4; text-figs. 21g, 22e, 25d), which has few, very widely spaced ribs, and is of Santonian age, as is *T. (T.) texanus gallica* Young, 1963 (p. 81, pl. 38, figs. 3, 4), which is very finely ribbed, with wider separation of the submarginal and external rows of tubercles. *T. (T.) texanus twiningi* Young, 1963 (p. 82, pl. 38, fig. 5; pl. 39, fig. 1; pl. 41, figs. 2, 5; pl. 48, fig. 4), has fewer ribs than *T. (T.) lonsdalei,* and is closer to the nominate subspecies. More problematic is *T. (T.) roemeri* Young, 1963 (p. 84, pl. 43, fig. 1), for as Matsumoto (1970: 295) noted, it shows a different arrangement of tubercles to the type material of the species. It resembles *T. (T.) lonsdalei* in the approximation of external and submarginal tubercle rows, but has very weak lateral tubercles that are spirally elongated, and rather coarser ribbing. *Texanites shiloensis* Young, 1963 (p. 89, pl. 46, figs. 1–4; pl. 54, figs. 4–7; pl. 70, figs. 5, 6, 8; text-fig. 24d) is a higher-whorled, densely ribbed species, better referred to *Plesiotexanites* Matsumoto, 1970 (see below).

OCCURRENCE: Uppermost Santonian and lowermost Campanian *S. tequesquitense* zone, Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic localities 282, 31472, 32112, and 32145. The type material is from the *S. tequesquitense* zone in Travis County, Texas.

Fig. 9. *Texanites* (*Texanites*) *lonsdalei* Young, 1963. USNM 486653, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone, Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 31472. Figure is ×1.

Subgenus *Plesiotexanites* Matsumoto, 1970

TYPE SPECIES: *Mortoniceras kawasakii* Kawada, 1929: 4, pl. 14, figs. 2–4, by original designation.

Texanites (*Plesiotexanites*) *shiloensis* Young, 1963
Figure 13

Texanites shiloensis Young, 1963: 89, pl. 46, figs. 1–4; pl. 54, figs. 4–7; pl. 70, figs. 5, 6, 8; text-fig. 24d.

Texanites shiloensis Young, 1963. Kennedy and Cobban, 1991: 179, fig. 8.30.

TYPE: The holotype is no. 1986 in the collections of the Texas Memorial Museum, from the Dessau Chalk on Brushy Creek, 23.2 km (12 mi.) south of Hutto, Williamson County, Texas.

DESCRIPTION: USNM 486656 (fig. 13) is a completely septate, worn composite mold with an estimated original diameter of 130 mm. Coiling is very evolute, with U = 33%

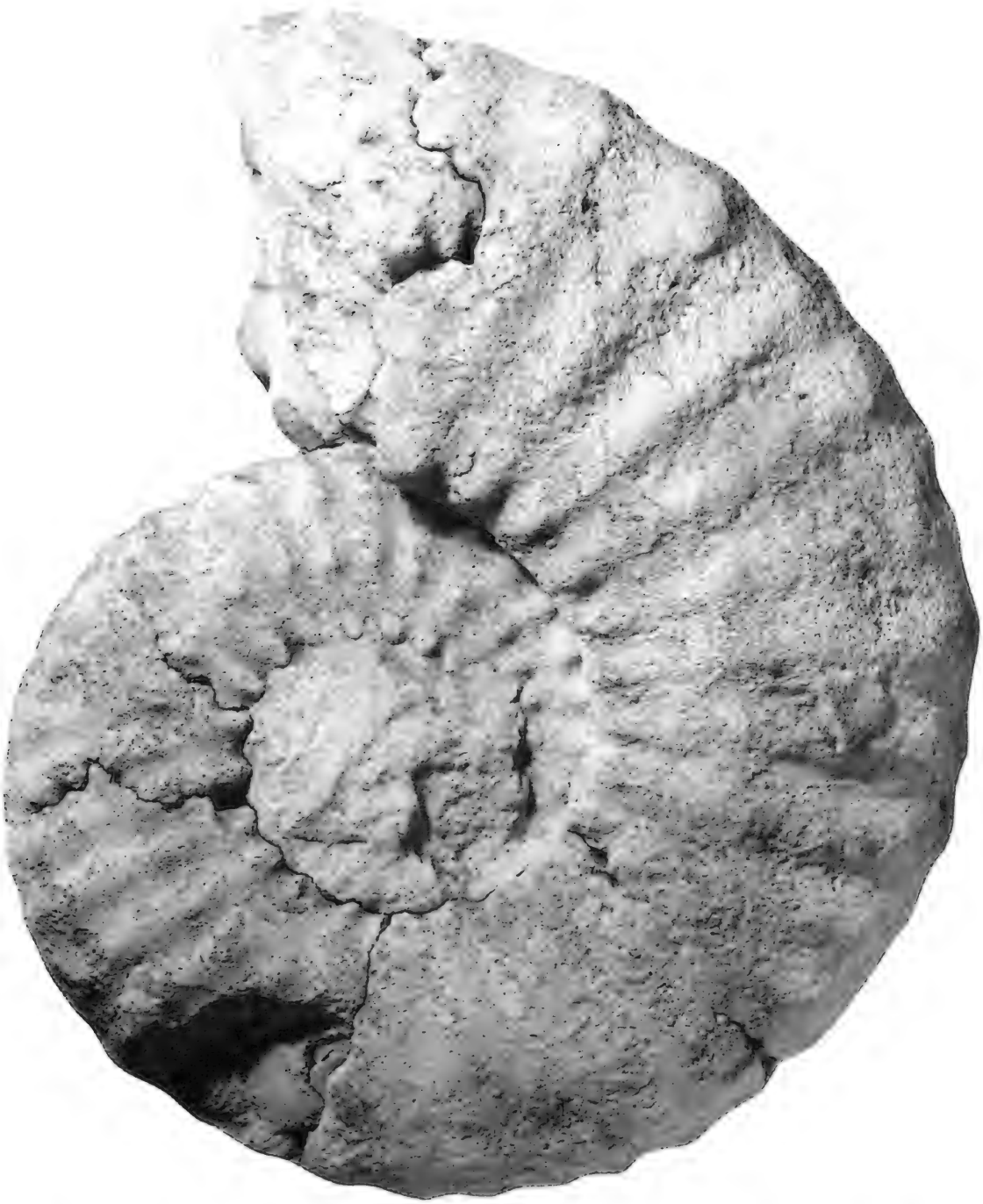


Fig. 10. *Texanites* (*Texanites*) *lonsdalei* Young, 1963. USNM 486654, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone fauna of the Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 32145. Figure is ×0.9 (actual diameter = 195 mm).

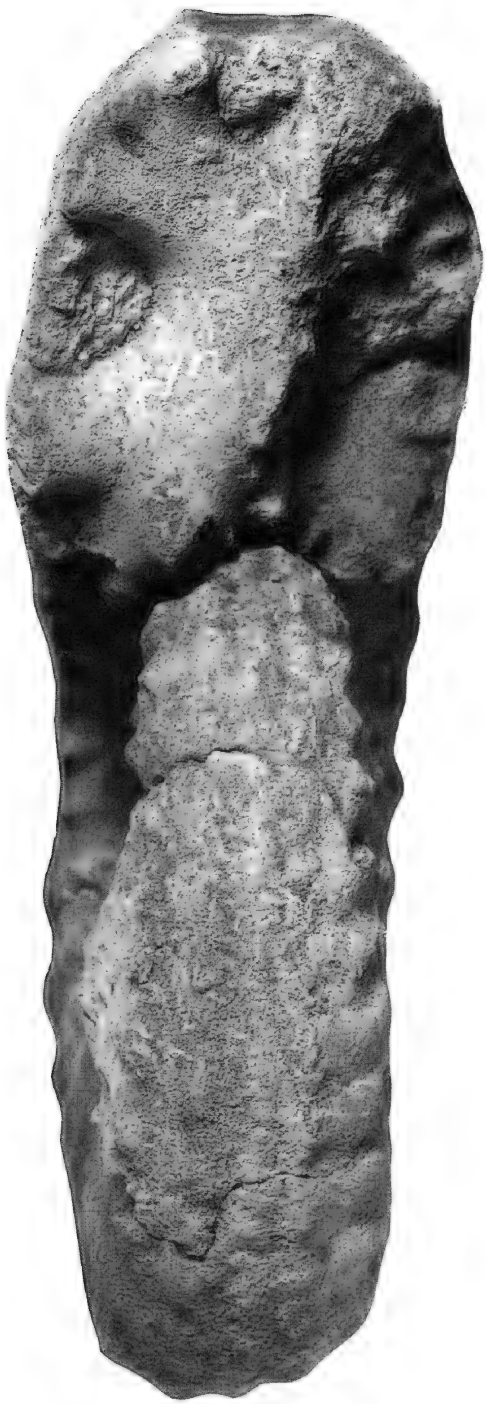


Fig. 11. *Texanites* (*Texanites*) *lonsdalei* Young, 1963. USNM 486654, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone fauna of the Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 32145. Figure is ×0.9 (actual diameter = 195 mm).

of diameter; the whorls overlap only to the level of the submarginal tubercles. The whorl section is compressed, with a ratio of whorl breadth to whorl height of 0.78. The umbilicus is shallow, with a markedly undercut umbilical wall; the umbilical shoulder is narrowly rounded and the flanks are flattened. There are an estimated 26–28 primary ribs on the last whorl. They strengthen across the umbilical wall into sharp, closely spaced umbilical bullae that project into the umbilicus. Blunt, straight prorsiradiate ribs arise, either singly or in pairs, from these bullae. A few intercalated ribs also arise on the flanks. There is a row of weak, rounded tubercles at midflank, a submarginal row of weaker tubercles, which is close to a marginal row of somewhat stronger clavate tubercles, each of which is linked by a low, broad rib to a strong, external clavus. A broad, smooth zone separates the external clavi from a strong siphonal keel.

DISCUSSION: Although poorly preserved, the tuberculation—with umbilical, lateral, submarginal, marginal, and external tubercles—indicates that this specimen is a *Texanites* (*Plesiotexanites*), and distinguishes it from *Texanites* (*Texanites*) in the present fauna. *T.* (*P.*) *shiloensis* differs from *Submortoniceras tequesquitense* Young, 1963 (p. 97, pl. 28, fig. 1; pl. 42, figs. 1, 2; pl. 44, figs. 4, 5; pl. 51, figs. 1, 2; pl. 52, figs. 1–4; pl. 57, fig. 4; pl. 70, fig. 1; text-figs. 12b, 28b), which also occurs in the present fauna, in its coarser ribbing and tuberculation, and persistence of the submarginal tubercles.

OCCURRENCE: Eutaw Formation, USGS Mesozoic locality 6925. This species first occurs in the upper Santonian, and is known from the Big Bend area in Texas and from the *Boehmoceras* fauna of the Tombigbee Sand Member in Mississippi (Kennedy and Cobban, 1991). In Texas, Young recorded it from the upper Santonian and lower Campanian. It is known from the Dessau Chalk in Hays, Travis, and Kinney counties; the San Carlos Formation of Presidio County; and Arroya Tecolote, Coahuila, Mexico.

Genus *Submortoniceras* Spath, 1926

TYPE SPECIES: *Mortoniceras woodsi* Spath, 1921: 232, pl. 21, fig. 1, by original designation.

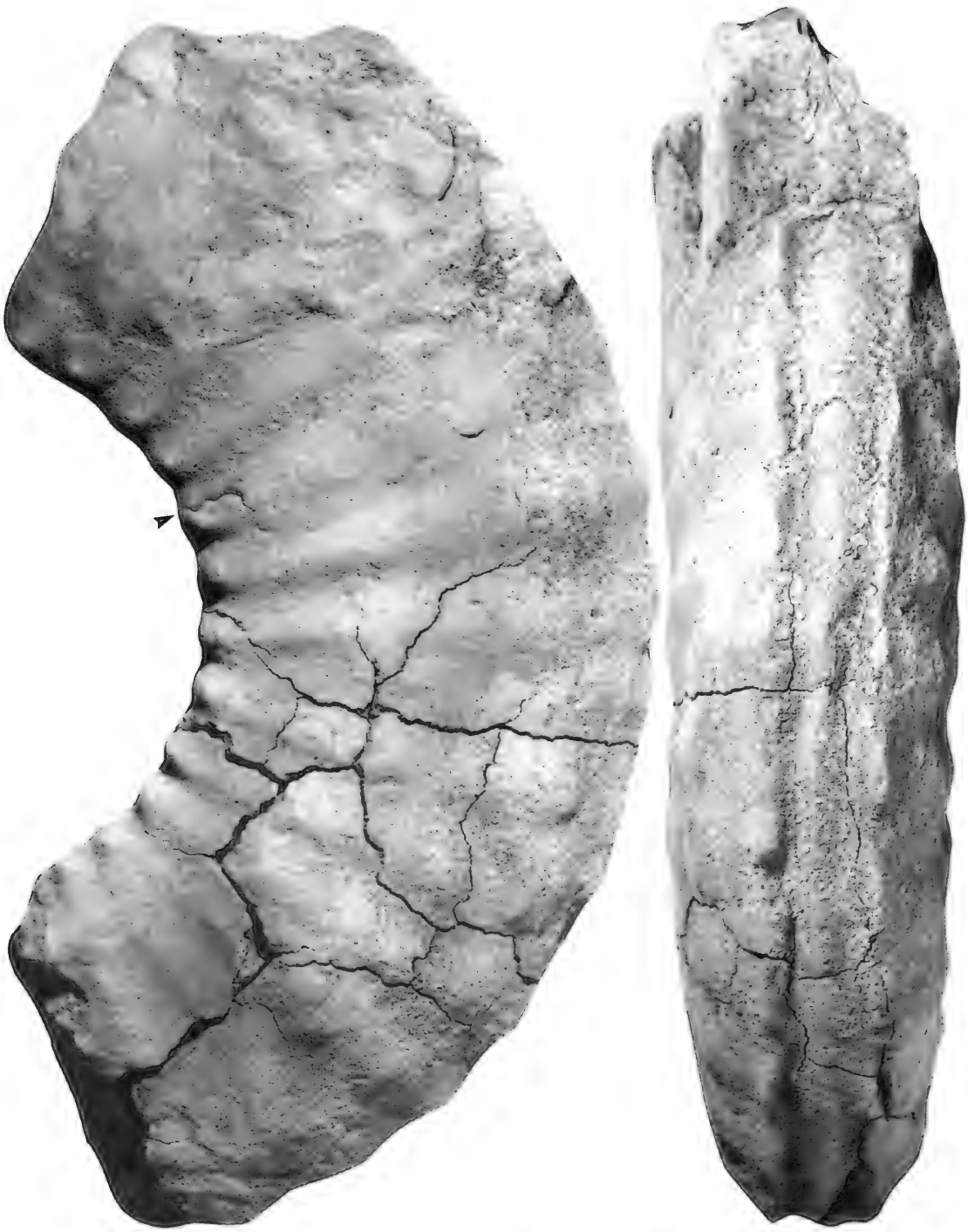


Fig. 12. *Texanites* (*Texanites*) *lonsdalei* Young, 1963. USNM 486655, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone fauna of the Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 282. Figure is ×0.9 (actual diameter = 200 mm).

Fig. 13. *Texanites* (*Plesiotexanites*) *shiloensis* Young, 1963. USNM 486656, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone fauna of the Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 6925. Figures are ×1.

Submortoniceras tequesquitense Young, 1963
Figures 14, 15

Submortoniceras tequesquitense Young, 1963: 97, pl. 28, fig. 1; pl. 42, figs. 1, 2; pl. 44, figs. 4, 5; pl. 51, figs. 1, 2; pl. 52, figs. 1–4; pl. 57, fig. 4; pl. 70, fig. 1; text-figs. 12b, 28b.
Submortoniceras tequesquitense Young, 1963. Cobban and Kennedy, 1991: B3, pl. 1, figs. 1, 2.

TYPE: The holotype is no. 34742 in the collections of the Texas Memorial Museum, Austin, and is from the upper part of the Dessau Chalk, "downstream from the concrete spillway of the new (1932) Del Rio-Eagle Pass highway crossing on Tequesquite Creek, Kinney County, Texas" (Young, 1963: 97).

DESCRIPTION: There are seven specimens in the present collections. USNM 486657 (fig. 14) shows the middle growth stages, well-preserved to a diameter of 140 mm. Coiling is very evolute, with U = 31% of diameter; the umbilicus is moderately deep with a low, undercut wall. An estimated 22–24 ribs arise at the umbilical seam, strengthen and sweep backward across the umbilical wall, and develop into sharp umbilical bullae that project into the umbilicus. Low, broad, blunt, straight, prorsiradiate ribs arise either singly or in pairs from these bullae. There is a row of weak, conical lateral tubercles situated some distance from midflank and separated by an equal distance from a row of barely visible, clavate submarginal tubercles. Each of these tubercles is connected by a low, broad rib to much stronger, elongate marginal and external clavi; the latter are separated by a wide, smooth sulcate zone from a strong, blunt siphonal keel.

USNM 486658 (fig. 15) is 250 mm in diameter, and retains the umbilical wall of a further one-half whorl. Coiling is moderately evolute, with U = 30% of diameter. There are 24 blunt umbilical bullae per whorl that give rise to low, broad ribs that efface markedly on the flanks; tubercles are weak to absent, except for elongate external clavi flanking the bisulcate-carinate venter.

DISCUSSION: The well-developed ribbing of the inner whorls of this species readily distinguishes it from the other Gulf Coast representatives of the genus described by Young (1963), including *S. sancarlosense* Young, 1963 (p. 100, pl. 55, figs. 1–4; pl. 62, fig. 3; text-figs. 20g, 27d); *S. mariscalense* Young, 1963 (p. 104, pl. 59, fig. 3; pl. 60, figs. 1, 4–6; text-figs. 14b, f), *S. uddeni* Young, 1963 (p. 105, pl. 5, figs. 1, 2, 4–9; pl. 60, figs. 2, 3, 7, 9, 10; text-figs. 14d, e, 28c), and *S. vandaliaense* Young, 1963 (p. 102, pl. 55, figs. 6, 7; text-fig. 26). *Submortoniceras vanuxemi* (Morton, 1834) of Young (1963: 98, pl. 54, fig. 3; pl. 56, fig. 2; pl. 57, fig. 7; pl. 58, fig. 3; pl. 67, fig. 3; pl. 69, figs. 1, 2, 6; text-figs. 12c, e; 26d, e) is a *Menabites* (*Delawarella*), discussed further below, while *S. candelariae* Young, 1963 (p. 102, pl. 56, figs. 1, 3, 4; pl. 60, fig. 8; text-figs. 20b, 28a, f, 29a, e, 34a, f) is a *Texanites* (*Plesiotexanites*) (Matsumoto, 1970: 279).

OCCURRENCE: *Submortoniceras tequesquitense* is the index fossil of the uppermost Santonian–lowermost Campanian ammonite zone in the Gulf Coast region, introduced by Young (1963). It occurs in the Tombigbee Sand Member at USGS Mesozoic localities 282, 6916, 25496, 31472, and 32112. In Texas, Young recorded it from the Dessau Chalk in Kinney, Travis, and Williamson counties. The J. P. Conlin collection, housed in Denver, has good specimens from the Porvenir area in Presidio County, Texas. One specimen (USNM 441433, not figured) from the upper 16 m (30 ft) of the Mancos Shale in sec. 6, T21N, R9E, Santa Fe County, New Mexico, is from the Western Interior zone of *Scaphites* (*Scaphites*) *hippocrepis* I.

Genus *Menabites* Collignon, 1948

TYPE SPECIES: *Menabites menabensis* Collignon, 1948: 7 (64), pl. 17, figs. 3, 4; pl. 18, fig. 1, by subsequent designation of Wright (1957: L432).

Subgenus *Delawarella* Collignon, 1948

TYPE SPECIES: *Ammonites delawarensis* Morton, 1830: 244, pl. 2, fig. 4, by original designation.

Menabites (*Delawarella*) *delawarensis* (Morton, 1830)
Figures 16, 17, 18D, E

Ammonites delawarensis Morton, 1830: 244, pl. 2, fig. 4.

Fig. 14. *Submortoniceras tequesquitense* Young, 1963. USNM 486657, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone fauna of the Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 25496. Figure is ×1.

Menabites (*Delawarella*) *delawarensis* Morton. Collignon, 1948: 29 (86) (with full synonymy).

Menabites (*Delawarella*) *delawarensis* (Morton, 1830). Kennedy, 1986: 81, pl. 3, figs. 3, 4 (with additional synonymy).

Menabites (*Delawarella*) *delawarensis* (Morton, 1830). Cobban and Kennedy, 1992a: 73, pl. 6, fig. 9.

Menabites (*Delawarella*) *delawarensis* (Morton, 1830). Cobban and Kennedy, 1992b: 445, figs. 4.6–4.9, 5.1, 5.2, 5.6, 5.7, 5.11–5.13.

Menabites (*Delawarella*) *delawarensis* (Morton, 1830). Kennedy and Cobban, 1993c: 836, figs. 5.10, 5.11, 9.5–9.13, 10.3, 11.1, 11.2, 11.4–11.6, 11.8, 11.9, 11.11.

Menabites (*Delawarella*) *delawarensis* (Morton, 1830). Kennedy et al., 1995: pl. 2, figs. 13, 14.

TYPES: The types are lost (see Reeside, 1962: 132; Kennedy, 1986: 81).

DESCRIPTION: There are four specimens in the present collections. USNM 486659 (fig.

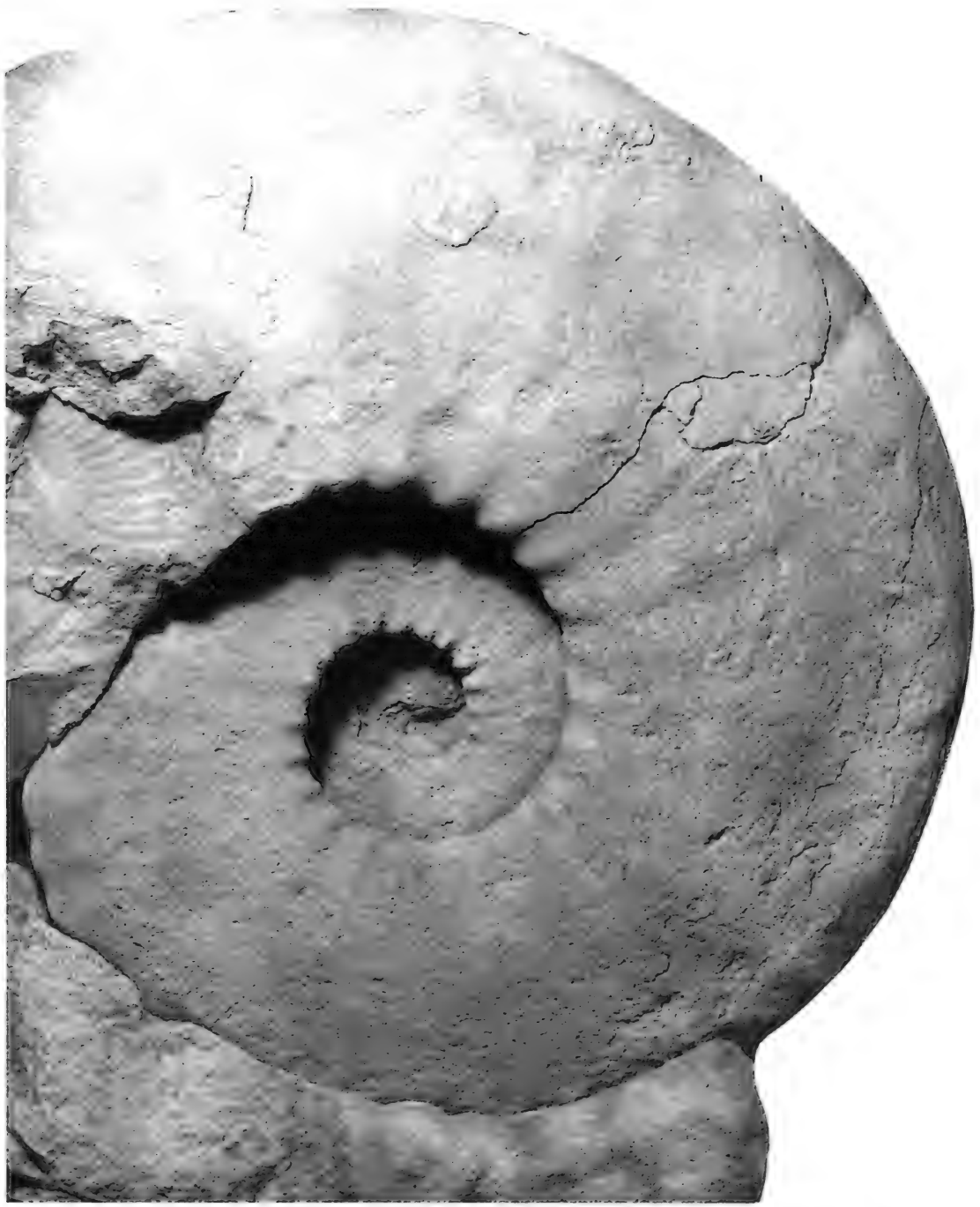


Fig. 15. *Submortoniceras tequesquitense* Young, 1963. USNM 486658, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone fauna of the Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 32112. Figure is ×0.7 (actual diameter = 250 mm).

Fig. 16. *Menabites* (*Delawarella*) *delawarensis* (Morton, 1834). USNM 486660, from the Campanian *Menabites* (*Delawarella*) *delawarensis* zone, Arcola Limestone Member, USGS Mesozoic locality 31557. Figures are ×1.

17) is a well-preserved composite mold with an original diameter of approximately 150 mm; USNM 486660 (fig. 16) is a distorted composite mold with an original diameter of approximately 100 mm; USNM 486661 (fig. 18D, E) is a highly distorted composite mold, with an original diameter of approximately 90 mm. Coiling is very evolute, with submarginal tubercles housed in notchs in the umbilical wall of the succeeding whorl. U = 29% of diameter; the umbilicus is deep, with a flat, vertical wall and narrowly rounded umbilical shoulder. The whorl section is depressed, with a ratio of whorl breadth to whorl height of 1.1; the greatest breadth occurs below midflank intercostally and at the lateral tubercles costally. The inner flanks are flattened and subparallel, the outer flanks broadly rounded and convex, and the venter broad. Primary ribs arise on the umbilical wall, where they are feebly rursiradiate. They strengthen into sharp bullae on the umbilical shoulder that number 25 or 26 per whorl on the outer whorl in USNM 486659. These bullae give rise to strong, straight prorsiradiate ribs. At the smallest diameter observed, each rib links to a strong, conical submarginal tubercle, that is linked, in turn, by a broad rib or not, to two external clavi. As size increases, each submarginal tubercle splits into a marginal clavus and conical submarginal tubercle, while a lateral tubercle de-

velops at a slightly later point in ontogeny. USNM 486661 has a full complement of tubercles at less than 50 mm diameter; USNM 486659 only develops the lateral row of tubercles at 80 mm diameter. A broad, smooth sulcate zone separates the external clavi from a strong, blunt siphonal keel. Sutures are not visible.

DISCUSSION: *Menabites (Delawarella) delawarensis* can be distinguished from co-occurring *M. (D.) danei,* Young, 1963, described below, by its denser ribbing, weaker tuberculation, and acquisition of lateral and marginal tubercles at a growth stage and size where *M. (D.) danei* retains coarse ribbing, with umbilical, submarginal, and external tubercles only. *M. (D.) vanuxemi* (Morton, 1834), described below, is a much more compressed, involute species with a smaller umbilicus, and tubercles subordinate to ribs.

OCCURRENCE: Campanian, *M. (D.) delawarensis* zone, Mooreville Formation, and especially the Arcola Limestone Member, USGS Mesozoic localities 31450, 31530, and 31557. This species also occurs in the Merchantville Formation in Delaware and New Jersey, and in the Austin Chalk in Travis County, Texas, in unit D of the Burditt Marl. It is present in the Big Bend National Park in Texas. It is common in the Roxton Limestone Member at the top of the Gober Chalk in Lamar County in northeast Texas, and in the Ozan Formation in Fannin County, Texas. Young (1963) recorded it from equivalents of the Gober Chalk in McCurtain County, Oklahoma. A single specimen is known from the lower Campanian of Aquitaine, France, and it occurs in the lower Campanian of Zululand (South Africa) and, possibly, Madagascar.

Menabites (Delawarella) vanuxemi (Morton, 1830)
Figure 18A

Ammonites vanuxemi Morton, 1830: 244, pl. 3, figs. 4, 5.

Submortoniceras vanuxemi (Morton). Reeside, 1962: 133, pl. 72, figs. 4, 5 (with full synonymy).

Submortoniceras vanuxemi (Morton). Young, 1963: 98, pl. 54, fig. 3: pl. 56, fig. 2; pl. 57, fig. 7; pl. 58, fig. 3; pl. 67, fig. 3; pl. 69, figs. 1, 2, 6; text-figs. 12c, e, 26d, e (with full synonymy).

Submortoniceras vanuxemi (Morton). Klinger and Kennedy, 1980: 232.

Menabites (Delawarella) vanuxemi (Morton, 1830). Cobban and Kennedy, 1991: B2, pl. 1, fig. 5; pl. 2, figs. 1–3.

Menabites (Delawarella) vanuxemi (Morton, 1830). Cobban and Kennedy, 1992a: 76, pl. 2, figs. 2–4.

Menabites (Delawarella) vanuxemi (Morton, 1830). Kennedy and Cobban, 1993c: 838, figs. 11.3, 11.7, 11.10, 11.11, 11.12, 12.5, 12.6, 12.17–12.19, 13.1.

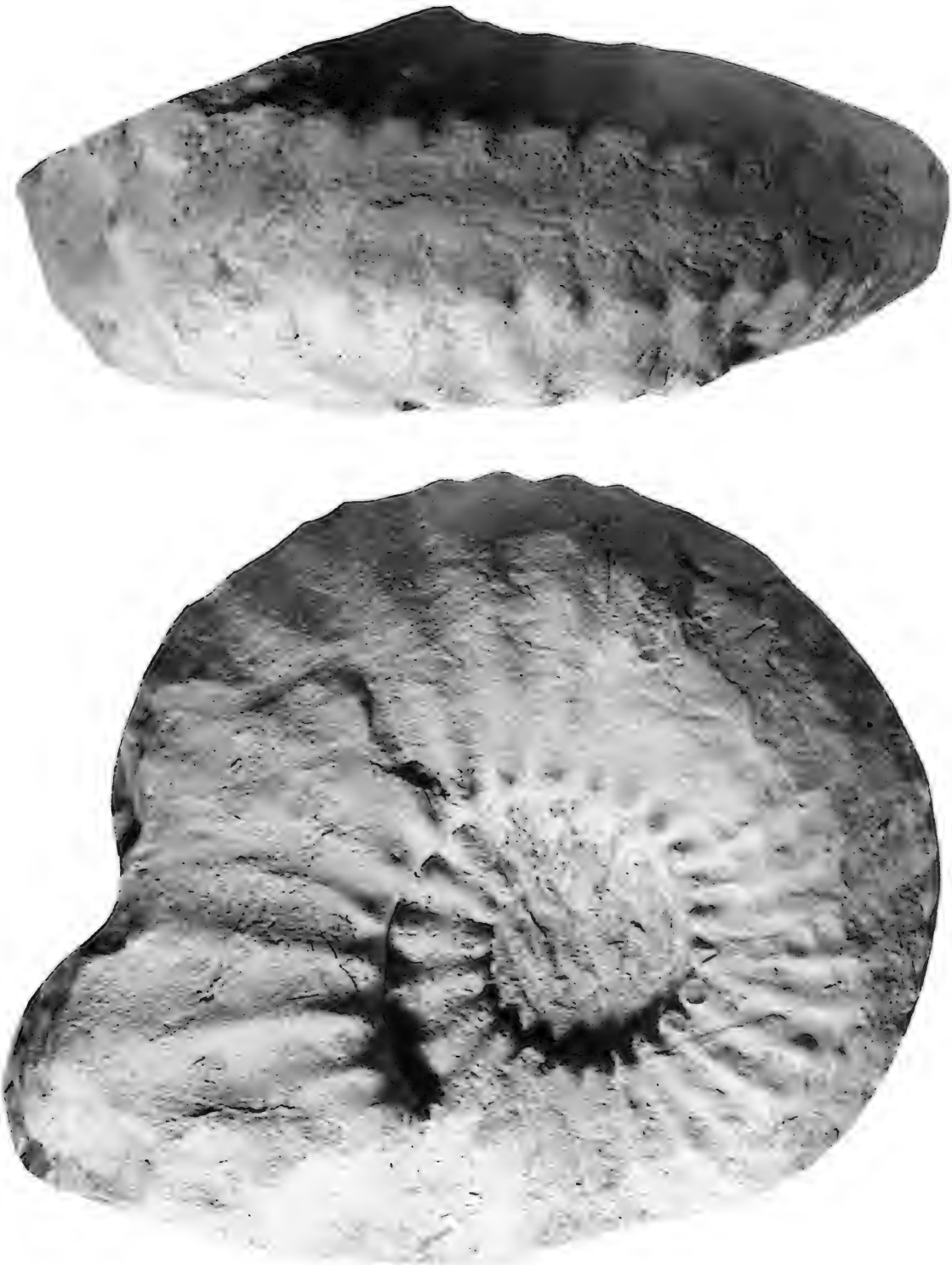
Menabites (Delawarella) vanuxemi (Morton, 1830). Kennedy et al., 1995: pl. 2, figs. 15, 16.

TYPE: The holotype, by monotypy, is no. 19492 in the collections of the Academy of Natural Sciences of Philadelphia, from the Chesapeake and Delaware Canal, Delaware, refigured by Reeside, 1962 (pl. 72, figs. 4, 5).

DESCRIPTION: USNM 486662 (fig. 18A) is a half-whorl fragment with a maximum preserved diameter of 75 mm. Coiling is involute, with U = 22% of diameter; the umbilicus is moderately deep, with a narrowly rounded umbilical shoulder. The whorl section is compressed, with a ratio of whorl breadth to whorl height of 0.86, the greatest breadth low on the flanks. Crowded umbilical bullae perch on the umbilical shoulder, and give rise to crowded prorsiradiate ribs, either singly or in pairs, with additional intercalated ribs. There are weak, bullate lateral tubercles, feeble clavate submarginals, and an equal number of stronger, clavate externals. A broad, sulcate, smooth zone separates the clavi in the external row from a strong siphonal keel.

DISCUSSION: Compressed whorls, involute coiling, crowded, weak ribs with umbilical, lateral, submarginal, and external tubercles from an early stage onward separate this species from both *Menabites (Delawarella) delawarensis* (Morton, 1834), described above, and *M. (D.) danei* Young, 1963, described below.

OCCURRENCE: Campanian, *M. (D.) delawarensis* zone, rubble derived from upper Arcola Limestone Member on the north side of Sumter County Road 1.2 km (0.7 mi.) east of Sumter High, Sumter County, Alabama. This species is also present in the Merchantville Formation, New Jersey, in the Austin



Chalk in Brewster and Travis Counties, Texas, and in sandstone beds in the San Carlos area of Trans-Pecos Texas. It occurs in the Roxton Limestone Member of the Gober Chalk in Lamar County, Texas, and in the Ozan Formation in Fannin County, Texas.

Menabites (Delawarella) danei (Young, 1963)
Figures 19, 20

Mortoniceras delawarensis (Morton). Dane, 1929: pl. 10, figs. 1, 2.
Delawarella danei Young, 1963: 114, pl. 57, fig. 6; pl. 62, figs. 1, 2; pl. 64, figs. 1, 5; pl. 65, figs. 1, 2; pl. 66, figs. 3, 4; text-figs. 24e, 33b.
Menabites (Delawarella) danei (Young, 1963). Cobban and Kennedy, 1991: B1, pl. 1, figs. 3, 4.
Menabites (Delawarella) danei (Young, 1963). Cobban and Kennedy, 1992a: 74, pl. 2, figs. 5–8; pl. 3, figs. 1–3; pl. 4, figs. 1, 12.
Menabites (Delawarella) danei (Young, 1963). Cobban and Kennedy, 1992b: 448, figs. 3.2–3.4, 5.5, 5.10.

TYPE: The holotype is no. 30646 in the collections of the Texas Memorial Museum, Austin, from "a formation equivalent to the Gober chalk" in McCurtain County, Oklahoma, 1.6 km (1 mi.) west of the Oklahoma-Arkansas boundary on route 3 from Foreman, Arkansas, to Torn, Oklahoma.

DESCRIPTION: The earliest growth stages observed are the inner whorls of USNM 486664 (fig. 19). Coiling is very evolute, with the submarginal tubercles housed in notches in the umbilical wall of the succeeding whorl. The umbilicus is broad and deep, with U = 36% of diameter; the umbilical wall is high, flattened, and subvertical and the umbilical shoulder is broadly rounded. The intercostal whorl section is depressed, with a ratio of whorl breadth to whorl height of 0.85, with broadly rounded flanks, more narrowly rounded ventrolateral shoulders, and a broad, flattened venter. The costal section is very depressed, with a ratio of whorl breadth to whorl height of 1.94 or more at the submarginal tubercles. At a diameter of 91 mm, there are 19 or 20 primary ribs per whorl. They arise at the umbilical seam, and are broad, straight, and rectiradiate across the umbilical wall. They develop into strong, conical umbilical tubercles perched on the umbilical shoulder. These give rise to strong, coarse, straight, prorsiradiate primary ribs that connect to massive submarginal tubercles. Many of these tubercles have a distinctive rounded top, and were clearly the bases of septate spines. Each submarginal tubercle is linked by a broad, prorsiradiate rib to a much weaker (but still prominent) external clavus, and by a weaker, less projected rib to a second external clavus, so that there are twice as many external as submarginal tubercles. A smooth zone separates the external clavi from a blunt, undulose siphonal keel.

This tritubercular stage extends to a diameter of 95 mm in USNM 486665 (fig. 20), beyond which the submarginal tubercles weaken progressively; each tubercle splits into two, a marginal clavus and a conical submarginal tubercle, while a lateral row of coarse, rounded tubercles develops progressively from about the same diameter. As size increases, the tubercles become more even in their development, and their dominance over the ribs decreases. This specimen retains part of the body chamber, and has 24 ribs at a diameter of 205 mm. Sutures are not visible.

DISCUSSION: The presence of a tritubercular stage with massive submarginal tubercles over a large part of ontogeny distinguishes *Menabites (Delawarella) danei* from most *Delawarella* species, including both *M. (D.) delawarensis* (Morton, 1834) and *M. (D.) vanuxemi* (Morton, 1834), described above.

OCCURRENCE: Campanian, *M. (D.) delawarensis* zone, Mooreville Formation, especially the Arcola Limestone Member, USGS Mesozoic localities 31530 and 31557. This species also occurs in the Roxton Limestone Member at the top of the Gober Chalk in Lamar County, Texas, and presumed

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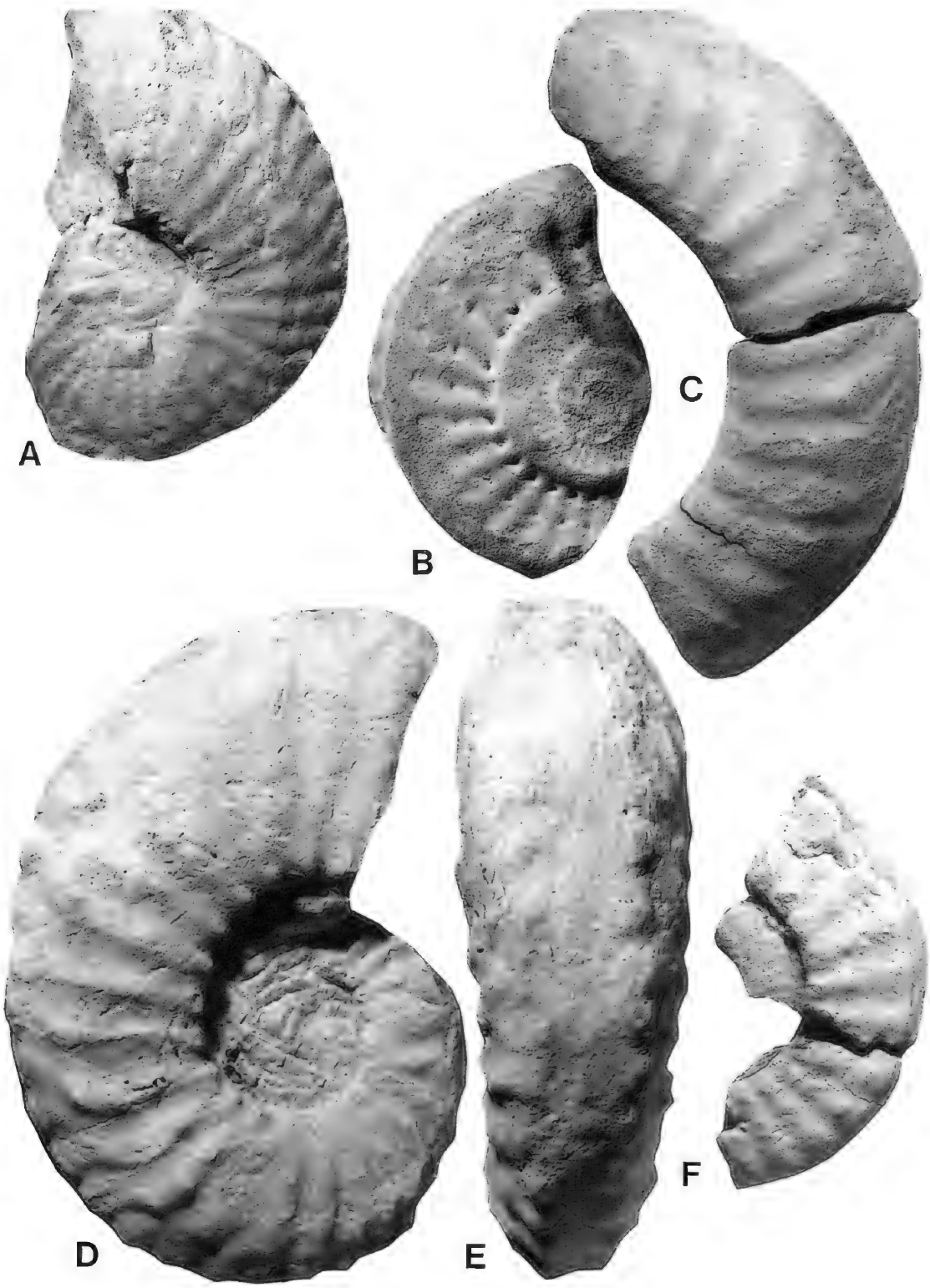
Fig. 17. *Menabites (Delawarella) delawarensis* (Morton, 1834). USNM 486659, from the Campanian *Menabites (Delawarella) delawarensis* zone, Arcola Limestone Member, USGS Mesozoic locality 31557. Figures are ×1.


A
B
C
D
E
F

equivalents in McCurtain County, Oklahoma (see under types), and in the Ozan Formation in Fannin County, Texas. Two specimens are known from the *Baculites obtusus* zone in the Pierre Shale near Pueblo, Colorado.

Genus *Reginaites* Reyment, 1957

TYPE SPECIES: *Peroniceras (Reginaites) quadrituberculatum* Reyment, 1957: 65, pl. 11, fig. 1; text-fig. 7, by original designation.

Reginaites reymenti Klinger and Kennedy, 1980
Figure 21

Reginaites reymenti Klinger and Kennedy, 1980: 111, figs. 86, 87a, b, 88.

TYPES: The holotype is SAS-Z1986, paratypes SAM-PCZ5877, 5887, and 5888, in the collections of the South African Museum, Cape Town, from the upper Santonian or lower Campanian of Die Rooiwalle, Lake St. Lucia, Zululand.

DESCRIPTION: USNM 486666 (fig. 21) is a crushed composite mold 165 mm in diameter, lacking internal whorls. Coiling is very evolute, with U = 43% of diameter; the umbilicus is shallow, with a broadly rounded umbilical wall. The original whorl section cannot be determined because of crushing. There are 17 massive umbilical bullae on the outer whorl, perched on the umbilical shoulder. They give rise to broad, straight recti- to prorsiradiate ribs that efface markedly across the flanks, only to strengthen again at massive, conical submarginal tubercles. A broad, transverse rib links each submarginal tubercle to a long marginal clavus. A sulcate smooth zone separates well-developed lateral keels from a stronger, undulose siphonal keel.

DISCUSSION: Strong umbilical and submarginal tubercles and three keels, the outer two linking weak marginal clavi, indicate that this crushed specimen is a *Reginaites*. The very coarse distant ornament is that of *Reginaites reymenti* Klinger and Kennedy, 1980 (p. 111, figs. 86, 87a, b, 88), from the upper Santonian or lower Campanian of Zululand, to which this specimen is referred. *Reginaites durhami* Young, 1963 (p. 92, pl. 39, fig. 2; pl. 49, figs. 1, 2, 4) is an upper Santonian species from Texas with slowly expanding, serpenticonic whorls having more numerous ribs and weaker tubercles, including a lateral row. *Reginaites leei* (Reeside, 1927) (p. 40, pl. 42, figs. 1, 2; pl. 43, figs. 3, 4) from the upper Santonian of New Mexico and Mississippi is much more densely ribbed, with much weaker tubercles than the present species. Other species are discussed by Klinger and Kennedy (1980).

OCCURRENCE: Lower Campanian, Mooreville Formation, 6.1 m (20 ft) above the base, at USGS Mesozoic locality 25404, 10.7 km (6.5 mi.) southwest of Montgomery, Montgomery County, Alabama. The types are from Zululand, and are imprecisely dated as upper Santonian to lower Campanian.

Genus *Neogauthiericeras* Collignon, 1969

TYPE SPECIES: *Neogauthiericeras zafimahovai* Collignon, 1969: 185, pl. 591, figs. 2236–2238, by original designation.

Neogauthiericeras n. sp., aff. *zafimahovai* Collignon, 1969
Figure 18B, C, F

DESCRIPTION: USNM 486667 (fig. 18B, C, F) is a series of fragments of the same individual with an estimated original diameter of 130 mm. Coiling is very evolute, the umbil-

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Fig. 18. **A.** *Menabites (Delawarella) vanuxemi* (Morton, 1834). USNM 486662, Campanian, *Menabites (Delawarella) delawarensis* zone, Arcola Limestone Member, rubble in field on north side of Sumter County Road, 0.7 mi. east of Sumter High, Sumter County, Alabama, **B, C, F.** *Neogauthiericeras* n. sp. aff. *zafimahovai* Collignon, 1969. USNM 486667, from the uppermost Santonian–lowermost Campanian *Submortoniceras tequesquitense* zone of the Tombigbee Sand Member of the Eutaw Formation, USGS Mesozoic locality 32146. **D, E.** *Menabites (Delawarella) delawarensis* (Morton, 1834). USNM 486661, from the Campanian *Menabites (Delawarella) delawarensis* zone, Arcola Limestone Member, USGS Mesozoic locality 31530. All figures are ×1.

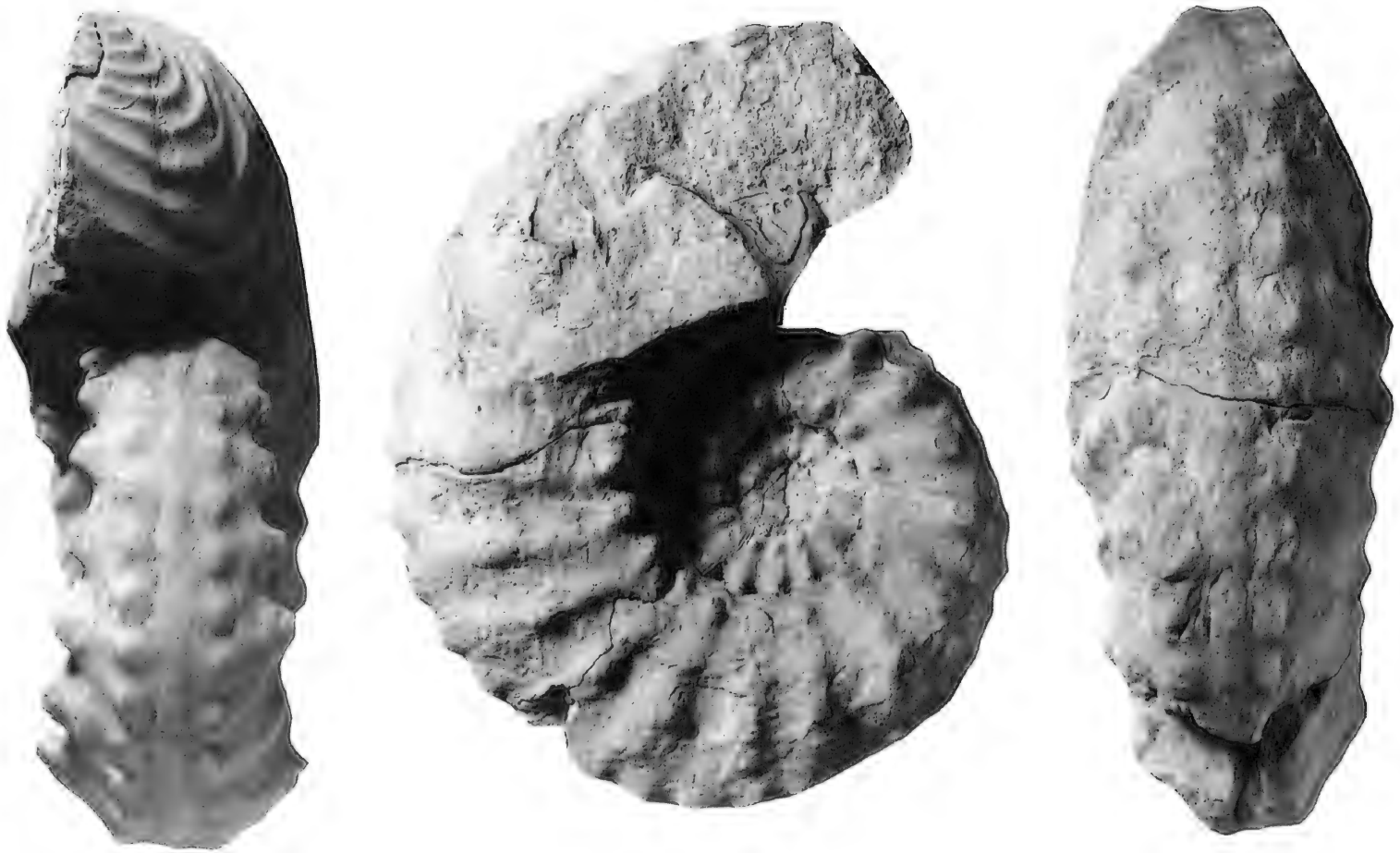
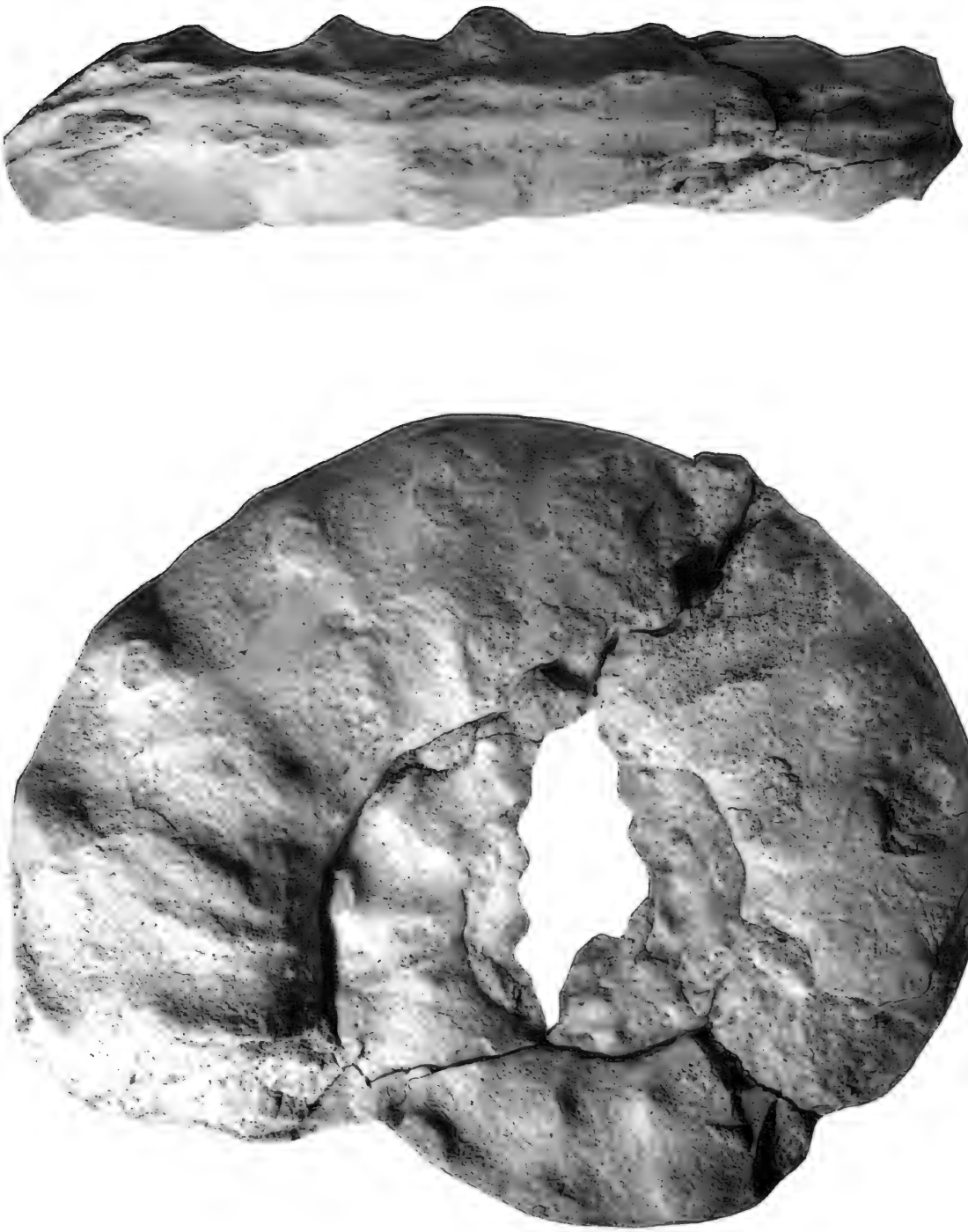


Fig. 19. *Menabites* (*Delawarella*) *danei* Young, 1963. USNM 486664, from the Campanian *Menabites* (*Delawarella*) *delawarensis* zone, Arcola Limestone Member, USGS Mesozoic locality 31530. Figures are ×1.

Fig. 20. *Menabites* (*Delawarella*) *danei* Young, 1963. USNM 486665, from the Campanian *Menabites* (*Delawarella*) *delawarensis* zone, Arcola Limestone Member, USGS Mesozoic locality 30687. Figure is ×0.8 (actual diameter = 220 mm).

icus broad and shallow, the umbilical wall feebly convex, and the umbilical shoulder more narrowly rounded. The whorls are compressed, and the expansion rate low. The ratio of whorl breadth to whorl height is 0.64, with the greatest breadth just outside the umbilical shoulder; the whorl section is lanceolate with a sharp, keeled venter. At the



smallest diameter observed, there are 15 ribs per half whorl. They arise at the umbilical seam and strengthen into blunt bullae, perched on the umbilical shoulder. These give rise to single, blunt, straight prorsiradiate ribs, each of which bears a small midlateral tubercle and a blunt, feebly clavate ventrolateral tubercle. These latter tubercles give rise to weaker, markedly prorsiradiate ribs that sweep forward and decline across the venter. On the outer whorl, the lateral tubercles merge with the ribs, and low, broad, straight prorsiradiate ribs, 18–20 per half whorl, arise at feeble umbilical bullae and link to progressively effacing, weak ventrolateral tubercles. These tubercles give rise to very weak, markedly prorsiradiate ribs that efface before reaching the siphonal keel.

DISCUSSION: USNM 486667 has suffered postmortem crushing, producing an artificially compressed whorl section. The outer whorl of the specimen closely resembles the type material of *Neogauthiericeras zafimahovai* Collignon, 1969 (p. 185, pl. 591, figs. 2236–2238; see also Kennedy and Cobban, 1990: 59, fig. 2), but the presence of lateral tubercles distinguishes it from that species. Klinger and Kennedy (1980) suggested that *Neogauthiericeras* was derived from *Reginaites* Reyment, 1957, some species of which have lateral tubercles, and it may be that the present specimen preserved this aspect of the ancestral condition in its early ontogeny. It clearly represents a new species of *Neogauthiericeras* but is inadequate for formal description.

OCCURRENCE: Upper Santonian, *S. tequesquitense* zone, Tombigbee Sand Member of Eutaw Formation at USGS Mesozoic locality 32146.

SUBORDER ANCYLOCERATINA WIEDMANN, 1966

SUPERFAMILY TURRILITACEAE GILL, 1871

FAMILY NOSTOCERATIDAE HYATT, 1894

Genus *Eubostrychoceras* Matsumoto, 1967

TYPE SPECIES: *Eubostrychoceras indopacificum* Matsumoto, 1967: 333, pl. 18, fig. 1.

Eubostrychoceras sp.

DISCUSSION: USNM 486668 (unfigured) is a 16 mm long fragment with a whorl height of 10 mm. The outer whorl face is convex, and ornamented by even prorsiradiate ribs; the rib index is 8. Although specifically indeterminate, the specimen demonstrates the presence of *Eubostrychoceras* in the Arcola Limestone Member.

OCCURRENCE: Campanian, *M. (D.) delawarensis* zone, Arcola Limestone Member at USGS Mesozoic locality 31530.

FAMILY DIPLOMOCERATIDAE SPATH, 1926

SUBFAMILY DIPLOMOCERATINAE SPATH, 1926

Genus *Glyptoxoceras* Spath, 1925

TYPE SPECIES: *Hamites rugatus* Forbes, 1846: 117, by original designation of Spath, 1925: 31.

Glyptoxoceras sp.
Figure 22C–E

DESCRIPTION: The most complete specimen, USNM 486669 (fig. 22E), consists of 1¼ loosely coiled planispiral whorls with a maximum diameter of 46 mm. The whorls expand slowly, with a compressed oval whorl section. Ribs are weak across the dorsum, strengthening on the dorsolateral area, and narrow, sharp, straight and recti- to feebly rursiradiate on the flanks; on the venter they are transverse and separated by much wider interspaces; the rib index is 7. USNM 486670 (fig. 22C, D) is part of a whorl that has a rib index of 7.

OCCURRENCE: Campanian, *M. (D.) delawarensis* zone, Mooreville Formation, especially Arcola Limestone Member, USGS Mesozoic localities 31433 and 31530. Closely similar specimens occur in the Ozan For-

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Fig. 21. *Reginaites reymenti* Klinger and Kennedy, 1980. USNM 486666, from the lower Campanian Mooreville Formation, USGS Mesozoic locality 25404. Figures are ×0.9 (actual diameter = 165 mm).

mation in Fannin County, Texas (Cobban and Kennedy, 1992a).

FAMILY BACULITIDAE GILL, 1871

Genus *Baculites* Lamarck, 1799

TYPE SPECIES: *Baculites vertebralis* Lamarck, 1801: 103, by subsequent designation of Meek, 1876: 391.

Baculites sp. group of *aquilaensis* Reeside, 1927
Figure 22I

Compare:
Baculites aquilaensis Reeside, 1927: 12, pl. 6, figs. 11–13; pl. 8, figs. 1–14.
Baculites aquilaensis var. *separatus* Reeside, 1927: 12, pl. 8, figs. 15–21; pl. 9, figs. 6–15; pl. 45, figs. 5, 6.
Baculites aquilaensis var. *obesus* Reeside, 1927: 12, pl. 10, figs. 1–8.

DESCRIPTION: The Arcola Limestone Member yields a rather variable suite of *Baculites*; there are 12 specimens in the present collections. Some juveniles are smooth. Feebly ornamented individuals are compressed with an ovoid whorl section, the venter more narrowly rounded than the dorsum. There are distant, crescentic ribs on the dorsal flank, with a rib index of 1–1.5. The ribs sweep forward and weaken markedly on the outer flank, breaking down into riblets and striae, which also intercalate between the ribs. The ornament flexes backward and is convex over the ventrolateral area, crossing the venter in a broad convexity. The most robustly ornamented variants are characterized by distant, crescentic dorsolateral bullae and strongly prorsiradiate riblets on the ventral flank and venter. Sutures are not visible.

DISCUSSION: This assemblage of rather generalized *Baculites* has many of the characters of the group of *B. aquilaensis* Reeside, 1927. The feebly ornamented variants are close to the variety *separatus* (Reeside, 1927: pl. 8, figs. 15–21; pl. 9, figs. 6–15), but the Arcola specimens have more widely spaced ribs. Comparable material occurs in the Ozan Formation in Fannin County, Texas (Cobban and Kennedy, 1992a).

OCCURRENCE: Campanian, *M.* (*D.*) *delawarensis* zone, Arcola Limestone Member at USGS Mesozoic localities 25465, 31433, 31530, 31557, and 32942.

Baculites taylorensis Adkins, 1929
Figures 22A, B, F–H, J–M, 23

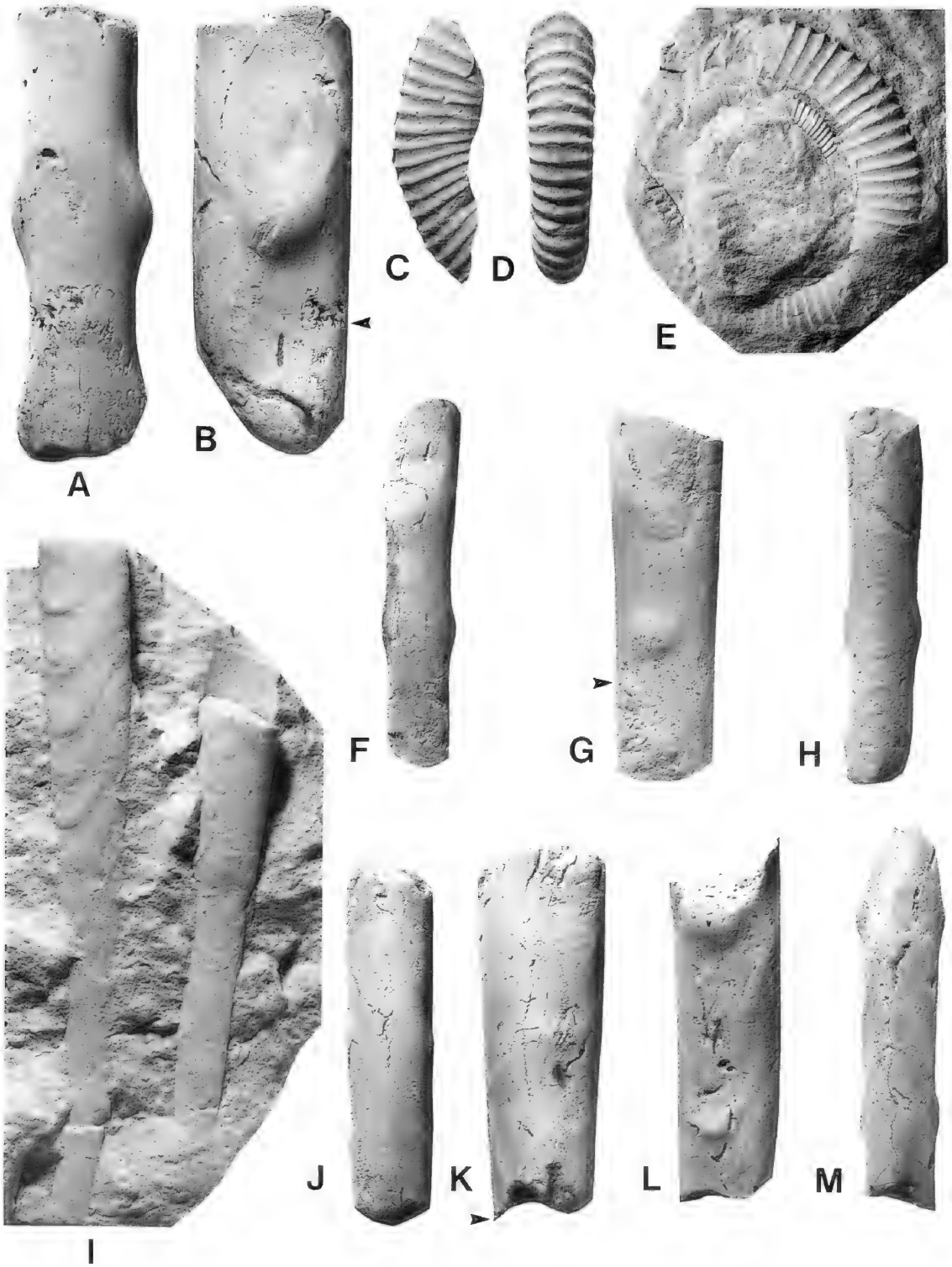
Baculites taylorensis Adkins, 1929: 204, pl. 5, figs. 9–11.
non Baculites cf. *taylorensis* Adkins. Collignon, 1970: 13, pl. 612, fig. 2785.
Baculites taylorensis Adkins, 1929. Kennedy and Cobban, 1993a: 143, pl. 6, figs. 1–9; pl. 7, figs. 1–6, 10–13; text-figs. 8b, d.
Baculites taylorensis Adkins, 1929. Kennedy and Cobban, 1993b: 93, figs. 10.1–10.9, 10.11, 10.12, 10.16, 10.18, 10.19, 11.1, 11.2.
Baculites taylorensis Adkins, 1929. Cobban and Kennedy, 1994: D6, pl. 3, pl. 4, figs. 5–19; text-fig. 7.

TYPES: The holotype is no. 21014, paratypes nos. 21015, 6, in the Bureau of Economic Geology Collections, in the Texas Memorial Museum, Austin, Texas. They are from the Pecan Gap Chalk 12.4 km (7.5 mi.) northeast of Austin on Manor Road, Travis County, Texas.

DESCRIPTION: There are more than 100 phosphatized specimens in the present collections. The shell expands slowly. The whorl section is a compressed oval with broadly rounded dorsum and inner flanks, convergent outer flanks, and a more narrowly rounded venter. All specimens are strongly

→

Fig. 22. **A, B, F–H, J–M.** *Baculites taylorensis* Adkins, 1929. **A, B.** USNM 486673, USGS Mesozoic locality 31532; **F–H.** USNM 486674, USGS Mesozoic locality 31561; **J, K.** USNM 486676, USGS Mesozoic locality 31532; **L, M.** USNM 486675, USGS Mesozoic locality 31532. All specimens are from the Campanian *Baculites scotti* zone fauna of the phosphatic nodule beds at the base of the Demopolis Formation. **I.** *Baculites* sp. group of *aquilaensis* Reeside, 1927. USNM 486671, USGS Mesozoic locality 32942. **C–E.** *Glyptoxoceras* sp. **C, D.** USNM 486670, USGS Mesozoic locality 31530; **E.** USNM 486669, USGS Mesozoic locality 31485. Both specimens are from the Campanian *Menabites* (*Delawarella*) *delawarensis* zone, Arcola Limestone Member. All figures are ×1.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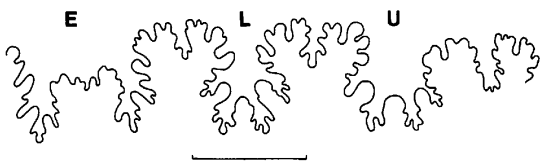

Fig. 23. *Baculites taylorensis* Adkins, 1929. Suture line of USNM 486672, from the Campanian *Baculites taylorensis* zone fauna of the phosphatic nodule beds at the base of the Demopolis Formation, USGS Mesozoic locality 31532. Scale bar = 10 mm.

ornamented, with strong, crescentic, concave dorsolateral nodes, each node occupying a distance equal to the whorl height, or even more widely spaced. The nodes are most prominent close to the dorsolateral shoulder. They give rise to delicate, low, feebly convex ribs on the dorsum. On the ventral half of the flanks, the nodes pass into progressively weakening, strongly prorsiradiate ribs, while additional weak ribs and striae intercalate over the entire surface of the flanks, or only the ventral half and project strongly forward. The ribs strengthen and cross the venter in a relatively narrow convexity, and may produce a distinctive, even, scalelike decoration.

The suture is illustrated in figure 23. E is broad with a broad median saddle; E/L is broad-stemmed and rectangular, with shallow incisions, as is L/U; L is narrow-necked, with deep, narrow incisions; and U is broader.

DISCUSSION: *Baculites taylorensis* is characterized by its very distant coarse nodes, rather than crescentic ribs. This distinguishes it from *Baculites* of the *aquilaensis* group, described above, and other species occurring in the lower and middle Campanian of the Gulf Coast and the Western Interior such as *Baculites mclearni* Landes, 1940 (Cobban, 1962: 712, pl. 165, fig. 15; pl. 107, figs. 17–19; text-figs. 1g, h), *Baculites scotti* Cobban, 1958 (p. 660, pl. 90, figs. 1–9), and *Baculites reduncus* Cobban, 1977 (p. 459, figs. 2–6).

OCCURRENCE: Campanian, *Baculites taylorensis* zone, base of the Demopolis Formation, USGS Mesozoic localities 31532, 31558, 31561, and 31592; Pecan Gap Chalk in central and northeast Texas; basal phosphate bed of Annona Chalk in Hempstead and Howard counties, Arkansas.

SUPERFAMILY SCAPHITACEAE GILL, 1871

FAMILY SCAPHITIDAE GILL, 1871

SUBFAMILY SCAPHITINAE GILL, 1871

Genus and subgenus *Scaphites* (*Scaphites*) Parkinson, 1811

TYPE SPECIES: *Scaphites equalis* J. Sowerby, 1813: 53, pl. 18, figs. 1–3, by subsequent designation of Meek, 1876: 413.

Scaphites (*Scaphites*) *hippocrepis* (DeKay, 1828) II Cobban, 1969
Figure 24D

Scaphites hippocrepis DeKay II. Cobban, 1969: 19, pl. 2, figs. 18–37; pl. 5, figs. 5–18, 24–27, 33–35; text-fig. 18.

DESCRIPTION: USNM 486677 is a crushed macroconch 38.5 mm long (fig. 24D). The spire is ornamented by rather coarse primary ribs that increase by branching and intercalation on the middle and outer flanks. The body chamber is ornamented by two umbilicolateral bullae in the transition zone between the shaft and hook, with bullate to conical ventrolateral tubercles on the adapertural section of the shaft and hook. These tubercles weaken markedly on the hook just adapical of the adult aperture. Ribs also weaken toward the adult aperture.

DISCUSSION: Although crushed, this specimen is clearly *Scaphites* (*Scaphites*) *hippocrepis*. Ornament of the body chamber, with strong umbilicolateral and rounded ventrolateral tubercles, plus lack of any trace of additional nodes on the final sector of shaft and hook show it to be form II of Cobban (1969).

OCCURRENCE: Upper part of Mooreville Formation, right bank of Tombigbee River at China Bluff, about 2 km (1.2 mi.) below Warsaw, in the NE ¼ NE ¼ sec. 5, T22N, R2W, Sumter County, Alabama; USNM 486677 is from between 2.4 and 4 m (3–13 ft) above the base of the bluff. *S. hippocrepis* II occurs in the Western Interior in Montana, Colorado, and Wyoming. Transitions between *S. hippocrepis* II and III occur widely in Assize P^{1-2} in the Campanian type area of Aquitaine, France and elsewhere in Europe, as discussed by Kennedy and Jagt (1995).

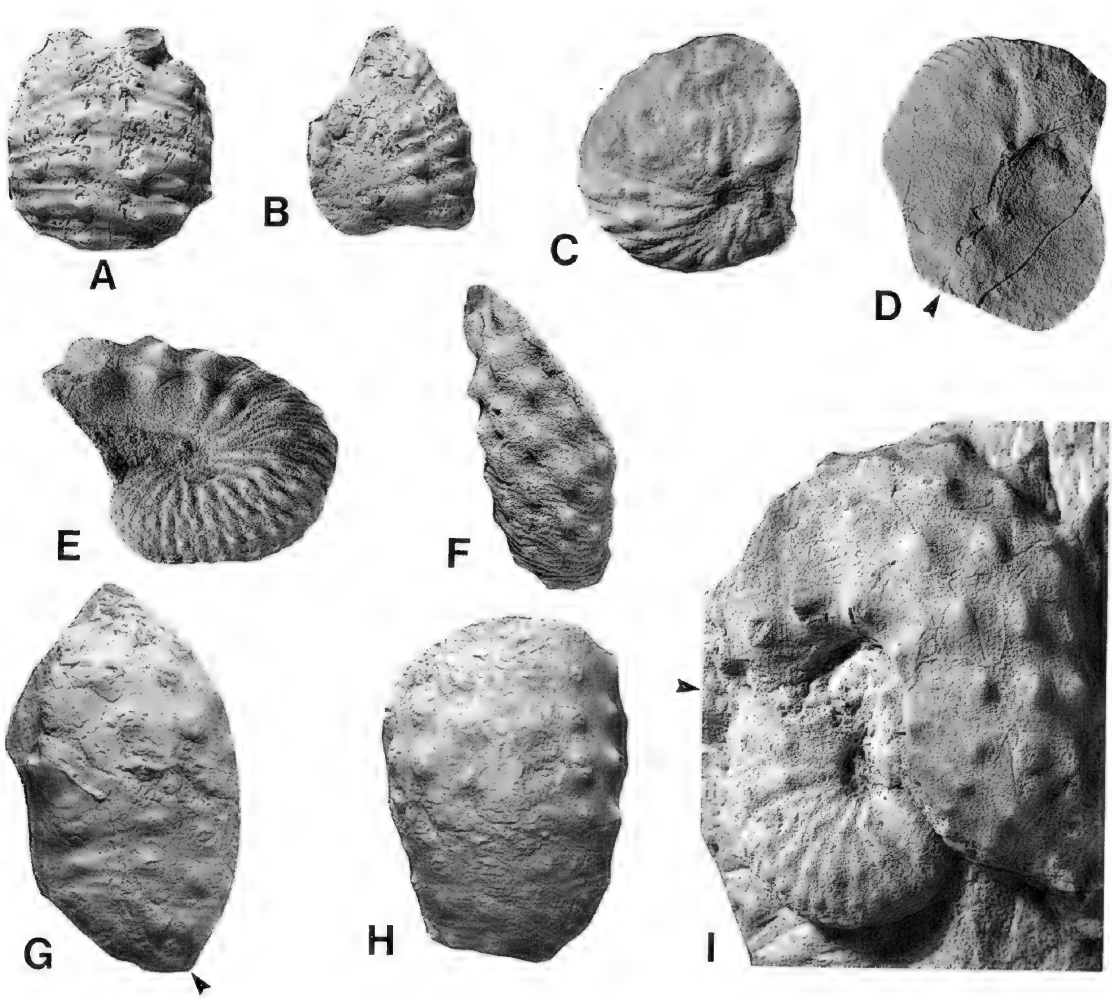

Fig. 24. **A, B, E–I.** *Trachyscaphites spiniger* (Schlüter, 1872) *porchi* (Adkins, 1929). **A, B.** USNM 445293, USGS Mesozoic locality 31532; **E, F.** USNM 486679, USGS Mesozoic locality 32956; **G, H.** USNM 486680, locality unknown; **I.** USNM 445294, USGS Mesozoic locality 31359. All specimens are from the Campanian *Baculites scotti* zone fauna of the Mooreville Formation. **C.** *Trachyscaphites spiniger spiniger* (Schlüter, 1872). USNM 486678, USGS Mesozoic locality 33296. **D.** *Scaphites* (*Scaphites*) *hippocrepis* (DeKay, 1828) II Cobban, 1969. USNM 486677, USGS Mesozoic locality 33296, Mooreville Formation. All figures are ×1.

Genus *Trachyscaphites* Cobban and Scott, 1964

TYPE SPECIES: *Trachyscaphites redbirdensis* Cobban and Scott, 1964: E7, pl. 1, figs. 1–7; text-fig 3, by original designation.

Trachyscaphites spiniger spiniger (Schlüter, 1872)

Figure 24C

Scaphites spiniger Schlüter, 1872: 82, pl. 25, figs. 1–7.

Trachyscaphites spiniger (Schlüter, 1872). Kennedy, 1986: 130, pl. 22, fig. 4; text-fig. 42 (with full synonymy).

TYPES: The lectotype, by the subsequent designation of Błaszkiewicz (1980: 31) is the original of Schlüter (1872: pl. 25, figs. 1–3), a macroconch from the upper Campanian of Darup, Westphalia, Germany, an unregistered specimen in the collections of the Geologisches und Paläontologisches Institut of Bonn University. Paratypes no. 61a and b are

in the same collections, and are the originals of Schlüter (1872: pl. 25, figs. 4, 6) from the Hügelgruppe of Haldem, Westphalia, Germany. They were refigured by Kennedy (1986, text-fig. 42).

DESCRIPTION: USNM 486678 (fig. 24C) is a crushed composite mold of a phragmocone with a maximum preserved diameter of 40 mm. Coiling is very involute, with a tiny, conical umbilicus. The original whorl section cannot be reconstructed. Coarse primary ribs are straight and prorsiradiate on the inner flank, with weaker ribs arising either singly or in pairs between. Ribs bear initially weak umbilicolateral bullae that strengthen markedly with increasing diameter. Ribs may branch from these bullae or not, and link, either singly or in pairs, to coarse outer lateral tubercles, with nontuberculate ribs between. Delicate wiry ribs arise in pairs from the outer lateral tubercles, and loop to inner and then to outer ventrolateral tubercles, with nontuberculate ribs between, so that the whole of the outer flanks and venter are covered by fine ribs that loop, zigzag, and intercalate between the tubercles.

DISCUSSION: Complex ribbing and tuberculation show this specimen to be *Trachyscaphites spiniger spiniger,* and separate it from subspecies *porchi* Adkins, 1929 (p. 203, pl. 5, figs. 1–3), described below.

OCCURRENCE: USGS Mesozoic locality 33296, top of lowermost limestone bed of Arcola Limestone Member of Mooreville Formation, bluffs on right side of Tombigbee River at Swilleys Bend, 442 km (267.75 mi.) above Mobile, in the middle of the east edge of sec. 29, T21N, R1W, Sumter County, Alabama. The nominate subspecies also occurs in the Ozan Formation in Fannin County, Texas (Cobban and Kennedy, 1992a), and there is a specimen in the USGS collections from the Annona Chalk at USGS Mesozoic locality D12889 about 6.4 km east of Clarksville, Red River County, Texas. This species is regarded as an "upper" Campanian marker in Europe, with records from Germany, The Netherlands, Sweden, Poland, Russia, Ukraine, Armenia, and Turkmenistan.

Trachyscaphites spiniger (Schlüter, 1872)
porchi (Adkins, 1929)
Figure 24A, B, E–I

Scaphites porchi Adkins, 1929: 203, pl. 5, figs. 1–3.

Scaphites aricki Adkins, 1929: 206, pl. 5, figs. 7, 8.

Trachyscaphites spiniger (Schlüter) subspecies *porchi* Adkins. Cobban and Scott, 1964: E10, pl. 2, figs. 1–23; pl. 3, figs. 1–11; text-fig. 4.

Trachyscaphites spiniger (Schlüter, 1872) *porchi* Adkins, 1929. Cobban and Kennedy, 1994: D7, pl. 4, figs. 1–4; pl. 5, text-fig. 8.

TYPES: The holotype is no. 21011, paratypes nos. 21012, and 21013, in the collections of the Bureau of Economic Geology, now housed in the Texas Memorial Museum, Austin, and from the Pecan Gap Chalk on the Austin-Manor Road, 12.4 km (7.5 mi.) northeast of Austin, Travis County, Texas.

DESCRIPTION: There are five specimens in the present collections. Phragmocones are as in *Trachyscaphites spiniger spiniger* described above. USNM 486679 (fig. 24E, F) is a crushed microconch, originally more than 55 mm long. Body chamber ornament on the composite mold consists of strong umbilical, lateral, and inner and outer ventrolateral tubercles, without any indication of ribs, although these are prominent on the phragmocone. USNM 486680 (fig. 24G, H) is a phosphatic fragment of the adapical end of the body chamber. The older part shows delicate ribs in addition to the tubercles, the younger part lacking all trace of ribs. USNM 445294 (fig. 24I) is a much larger microconch, again showing loss of ribs on the body chamber.

DISCUSSION: Lack of ribs on most of the body chamber distinguishes *Trachyscaphites spiniger porchi* from the nominate subspecies, showing the present specimens to belong to the former, rather than the latter.

OCCURRENCE: Campanian, *Baculites taylorensis* zone, Demopolis Formation, USGS Mesozoic localities 31359, 31532, and 33296. This subspecies succeeds *Trachyscaphites spiniger spiniger* in northeast Texas, and is known from the Wolfe City Sand and Pecan Gap Chalk in northeast and central Texas, and from the Anacacho Limestone in southwest Texas. In the Western Interior, this subspecies occurs in the *Baculites mclearni* and *B. asperiformis* zones in the Claggett Shale in central Montana, in the Mancos Shale of the Grand Junction area in western Colorado, and in the Pierre Shale in the Golden-Littleton area, Colorado. It may also

be present in Israel (see discussion in Cobban and Kennedy, 1992a, 1994).

ACKNOWLEDGMENTS

The late N. F. Sohl (formerly U.S. Geological Survey, Reston) offered us invaluable assistance with this project. The U.S. Geological Survey provided the specimens for study. C. W. Wright (Seaborough, Dorset, England), G. R. Scott (Scientist Emeritus, USGS, Denver, Colorado), and S. C. Hook (Texaco, Houston, Texas) critically reviewed earlier drafts of this manuscript. R. E. Burkholder, formerly of the U.S. Geological Survey, Denver, photographed some of the specimens. Kennedy acknowledges the financial support of the Natural Environment Research Council (U.K.), and the technical assistance of the staff of the Geological Collections, University Museum, Oxford, and Department of Earth Sciences, Oxford. Landman acknowledges the assistance of B. Worcester and S. Crooms (both AMNH).

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